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Does Central Bank Transparency Influence the Effects of Quantitative Easing on Banking System Vulnerability?

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Abstract

After the global financial crisis, central banks used unconventional monetary policies, including quantitative easing (QE), to restore financial stability. Although several studies have analyzed the effects of these measures on financial markets, limited attention has been given to how central bank transparency influences the stability of commercial banks operating under these conditions. This study examines the impact of central bank transparency on national banking system vulnerability during periods of QE across eight economies from 2013 to 2019. Using a dynamic two-step generalized method of moments model based on bank-level data, the analysis includes bank-specific variables, monetary policy indicators, macroeconomic determinants, central bank characteristics, and structural factors of the banking sector and applies a fixed-effects panel regression model. The findings show that transparency moderates the effect of QE on bank vulnerability and strengthens banking system resilience. By emphasizing the role of central bank transparency as a key element of monetary policy, this research provides useful evidence for policymakers seeking to improve the effectiveness and credibility of unconventional monetary measures in different banking environments.

Keywords: bank vulnerability; monetary policy; central bank transparency; panel data

1. Introduction

Macro-financial research has long focused on the link between monetary policy and financial stability. The seminal studies by [Bernanke \(1983\)](#) and [Bernanke and Gertler \(1995\)](#) analyzed the transmission mechanisms through which monetary policy influences the real economy, emphasizing the credit channel as an important connection between monetary interventions and real economic outcomes. In this context, changes in policy rates or balance sheet operations affect banks' funding conditions, capital positions, and ultimately their lending practices.

Recent studies, including [Rodnyansky and Darmouni \(2017\)](#) and [Drechsler et al. \(2017\)](#), have shown that monetary policy has a significant impact on bank profitability, risk-taking, and overall financial health. Expansionary policies usually lower net interest margins and encourage investors to shift capital toward riskier assets. By contrast, tightening phases usually cause deleveraging and more stress on funding. These results highlight the dual function of monetary policy as both a stabilizing and potentially destabilizing influence on the banking system.

For decades, monetary policy has primarily focused on price stability, with central banks operating under the assumption that controlling inflation would inherently support



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financial stability. However, the 2008 systemic crisis challenged this notion, as financial instability emerged despite stable inflation. This raised concerns that monetary policy frameworks, especially those centered on inflation targeting, may have contributed to banking sector vulnerabilities by neglecting financial imbalances. The increasing reliance on unconventional monetary policy tools, such as QE and prolonged low interest rates, has further complicated this relationship. Although these measures were introduced to stabilize the economy, they may have also fueled excessive risk-taking, asset price distortions, and financial fragility within the banking sector. Given these concerns, this paper examines the extent to which monetary policy, both conventional and unconventional, affects banking vulnerability. By assessing key financial indicators, we aim to provide empirical evidence on whether central banks' policy priorities inadvertently heighten risks within the financial system (Levieuge et al., 2019).

Studying the impact of monetary policy on banking vulnerability is important because banks are closely interconnected, and distress in one institution can quickly spread to others. This happens either through direct links, such as contracts that transfer losses between banks, or through "fire sales," where banks sell assets to reduce their leverage, leading to falling prices and further distress. Monetary policy affects liquidity conditions and asset prices, which can increase or reduce banks' vulnerability. Understanding this relationship is essential for shaping policies that limit crisis contagion and strengthen the stability of the financial system (Greenwood et al., 2015).

This study builds on existing theoretical and empirical foundations by investigating the interplay between central bank transparency and QE in influencing the vulnerability of the banking sector. Previous research has largely concentrated on the direct impacts of monetary policy on profitability and stability; however, there is limited evidence on the communicative aspect of monetary policy and its moderating function in periods when unconventional tools are used. We examine whether central bank transparency affects the relationship between QE and macro-financial vulnerability by reducing uncertainty and improving the predictability of monetary policy. In addressing this gap, the study clarifies how monetary policy is transmitted through financial institutions and highlights the potential role of clear central bank communication during QE periods.

This study extends this area of research by examining the influence of central bank transparency on these relationships during quantitative easing (QE) periods. The primary objective and contribution of the study is to clarify the role of transparency in influencing the impact of unconventional monetary policies on banks' vulnerability. It examines whether transparent and predictable communication can alleviate the destabilizing effects of QE on credit dynamics and systemic risk.

To test this association empirically, the study combines country-level macro-financial data with bank-level balance sheet statistics for the period of 2013–2019. The initial dataset comprises more than 600 commercial banks from 37 economies. However, missing values and the requirement that all dependent, explanatory, control, and lagged variables be jointly available reduce the final complete-case samples to fewer banks and bank-year observations. A national banking system's vulnerability is measured by credit volatility and the credit-to-GDP gap. Both measures vary across country-years rather than across institutions within the same country-year. The explanatory variables include monetary policy indicators, such as short-term interest rates, broad money supply, and QE; macroeconomic variables, such as GDP growth and inflation; and bank-level characteristics, such as bank size, the equity-to-assets ratio, and off-balance-sheet activities. Market concentration is also included to capture differences in banking market structure.

The results indicate that the relationship between QE and national banking system vulnerability is dependent on central bank transparency. The conditional marginal effect of

QE generally declines as the transparency moderator increases, with the point estimates becoming more negative at higher transparency values. Accordingly, the findings are interpreted as evidence that transparent and predictable central bank communication influence the transmission of unconventional monetary policy, rather than as evidence that QE uniformly increases vulnerability or that transparency conclusively offsets such an effect.

The rest of the paper is organized as follows: Section 2 reviews the literature; Section 3 presents the data and methodology; Section 4 discusses the results; and Section 5 concludes.

2. Literature Review

Significant research has long emphasized that monetary policy operates not only through the standard interest rate mechanism, but also through broader financial and credit channels (Bernanke, 1983; Bernanke & Gertler, 1995). Within this broader framework, Bernanke and Blinder (1988) and Bernanke and Lown (1991) highlight the role of the bank lending channel. Kashyap and Stein (2000) further strengthen this view by demonstrating that monetary policy has stronger effects on the lending of smaller and less liquid banks. The characteristics of individual banks therefore condition the transmission of policy in ways that are empirically significant. More recent studies have drawn attention to the importance of the risk-taking channel. C. Borio and Zhu (2012) and Gambacorta (2009) provide evidence that the stance of monetary policy influences the perception and pricing of risk. Long periods of low interest rates, in particular, appear to encourage greater risk-taking among financial intermediaries. Woodford (2004) emphasizes that monetary policy also operates through the management of expectations. The effectiveness of policy depends to a considerable degree on the ability of central banks to shape beliefs about the future path of short-term interest rates. These channels provide the conceptual basis for much of the empirical literature on how policy actions and central bank communication affect bank resilience and systemic risk. This study extends the literature by examining how central bank transparency interacts with the transmission of unconventional monetary policy, an area that has received less attention than the individual policy channels themselves.

Foundational empirical work provides strong support for the bank risk-taking channel of monetary policy. Altunbas et al. (2010) report that when interest rates remain low for extended periods, banks tend to take more risk. Dell'Ariccia et al. (2014) show that a drop in real interest rates can increase leverage and encourage further risk-taking. Paligorova and Santos (2017) show that during accommodative-policy periods, banks charge narrower risk spreads to borrowers who are already quite risky. Building on these findings, Brana et al. (2018) extend the risk-taking channel to unconventional monetary policy. Using a dynamic panel model covering twenty European countries between 2000 and 2015, they find that monetary easing, captured by low policy rates, negative shadow rates, and expanding central bank balance sheets, makes banks more willing to take risks. The relationship appears to be nonlinear, and QE seems to be an important driver of the effect. Kandrak and Schlusche (2021) examine this pattern and find that QE, by increasing bank reserves, raises both lending and risk-taking. Banks that received larger reserve injections lent more and shifted their portfolios toward riskier market segments, including real estate, commercial and industrial loans, and consumer credit. This pattern is consistent with the portfolio rebalancing channel. The implication is that QE can make banks more comfortable with risk today, but it may also leave them more exposed over time. Pleșcău and Cocriș (2016) add further evidence to this connection. For Eurozone banks, they find that expansions of the European Central Bank (ECB) balance sheet drive Z-score values upward by a noticeable margin. A higher Z-score signals greater distance from insolvency and stronger bank stability. Their results suggest that QE strengthens bank stability, which in turn

reduces banks' risk aversion. In particular, this enhanced stability encourages higher bank risk-taking and increases their propensity to engage in risky activities, particularly during crisis times.

In the context of QE, [Krishnamurthy and Vissing-Jorgensen \(2011\)](#) identify several transmission mechanisms, most notably signaling, safety and liquidity channels, through which asset purchase programs affect interest rates and risk premiums across different asset classes. QE can directly affect banks' risk-taking incentives, valuation dynamics, and funding behavior by changing the relative yields of different asset classes, shifting expectations about future policy rates, and improving market functioning. This framework thus offers an important theoretical foundation for examining whether central bank transparency alters the impact of QE on bank vulnerability.

The bank risk-taking channel links monetary policy to financial vulnerability beyond standard transmission mechanisms. Evidence suggests that extended accommodative conditions, characterized by narrowed margins, abundant liquidity, and search-for-yield pressures, encourage leverage, riskier portfolio allocations, and more lenient lending standards, increasing the banks' exposure to market, credit, and liquidity risk ([Altunbas et al., 2010](#); [C. Borio & Zhu, 2012](#); [Dell'Ariccia et al., 2017](#)). [Bernanke and Gertler \(1995\)](#) show that extended accommodative conditions modify banks' incentives, reduce risk premiums, and encourage riskier portfolio allocations. Subsequent empirical research finds that low interest rates and unconventional policies, such as QE, may increase leverage, weaken credit standards, and encourage investment in long-duration or illiquid assets ([C. Borio & Zhu, 2012](#); [Dell'Ariccia et al., 2017](#)). When policy rates remain low and central banks buy more assets, banks often "reach for yield" by lending more to higher-risk borrowers. This can increase credit volatility and widen credit-to-GDP imbalances, the two important measures of vulnerability used in this study.

The empirical research examines the impact of key monetary policy tools, specifically QE, short-term interest rates (STR), and money supply (M3), on the risk-taking behavior of banks, as shown by credit volatility and the credit-to-GDP gap. Research indicates that accommodative monetary conditions influence leverage, portfolio risk, and lending standards ([C. Borio & Zhu, 2012](#); [Dell'Ariccia et al., 2017](#)), establishing a connection between monetary policy and banking vulnerability.

In this context, central bank transparency may have a moderating role. Clear communication about policy, exit options, and QE can help reduce uncertainty, stabilize expectations, improve the predictability of monetary policy, and limit abrupt market repricing ([Blinder et al., 2008](#); [Coenen et al., 2017](#); [Ehrmann & Fratzscher, 2007](#); [Papadamou et al., 2014a, 2016b](#)). This role appears particularly important in periods of unconventional monetary policy, when communication about asset purchase programs and forward guidance can reduce market uncertainty more effectively if it provides clear implementation details and a well-specified reaction mechanism ([Coenen et al., 2017](#)). Related evidence also shows that unconventional monetary policy announcements can lower perceived tail risks, especially through forward guidance ([Hattori et al., 2016](#)). Unclear or inconsistent communication, by contrast, can raise uncertainty, make policy less predictable, encourage speculation, and unsettle financial markets, all of which can increase economic fragility during periods of QE ([Blinder et al., 2008](#); [Born et al., 2014](#)).

Drawing on the risk-taking literature, the present study examines whether central bank transparency mitigates or amplifies the influence of QE on banking sector vulnerability. Previous research has addressed these elements separately. The effects of unconventional monetary easing on bank risk-taking have been investigated by looking at the risk-taking channel ([C. Borio & Zhu, 2012](#); [Brana et al., 2018](#)). The role of transparency in the transmission of monetary policy has been examined through the expectations channel, also referred

to as the management-of-expectations channel (Woodford, 2004). Little is known, however, about whether transparency affects the impact of unconventional monetary easing on bank vulnerability. This connection is of considerable importance. Transparency may shape expectations and reduce policy uncertainty through the expectations channel identified by Woodford (2004). It may also influence the perception and pricing of risk through the risk-taking channel discussed by C. Borio and Zhu (2012). In doing so, transparency may alter the strength with which the risk-taking channel operates under conditions of QE. By examining this interaction empirically, the study contributes to an area of the literature on unconventional monetary policy and financial stability that remains relatively underexplored. The analysis seeks to provide evidence that can help to clarify whether the clarity of central bank communication alters the effects of unconventional policy on the vulnerability of the banking system.

This potential moderating role of transparency fits with the wider literature. That research shows that central bank transparency makes monetary policy transmission stronger. A series of studies by (Papadamou et al., 2014a, 2014b, 2016a) points in this direction. The evidence suggests that, by helping expectations to be formed more clearly, greater transparency increases the predictability of interest rate changes and thus reduces the volatility in stock markets. It also lowers volatility in exchange rates, inflation, and output. This means that clearer communication from the central bank can strengthen the stabilizing force of monetary policy. In the context of unconventional monetary easing, this provides an additional reason to expect that transparency may shape, and potentially moderate, the effect of QE on banking sector vulnerability.

The literature suggests that central bank transparency can strengthen the effectiveness of monetary policy. It does so by reducing informational frictions and by lowering the degree of uncertainty in the economic environment. The present study asks whether transparency moderates the link between QE and bank fragility. Bank vulnerability is captured using indicators such as credit volatility and the credit-to-GDP gap. The analysis also controls for a set of relevant factors, such as bank-specific characteristics, macroeconomic conditions, monetary policy variables, and structural features of the banking sector. Bank vulnerability is a central dimension of financial stability. An understanding of the way in which monetary policy and transparency jointly shape it is therefore of considerable importance, both for researchers and for those who make policy.

Although research in this area has been substantial, the literature remains varied and not yet fully consolidated. A thorough review is needed to consolidate existing knowledge and highlight areas for future research, encouraging a clearer understanding of the subject.

With respect to other bank-specific variables that may affect bank vulnerability, Levieuge et al. (2019) demonstrate that bank size has a substantial impact on credit volatility and the credit-to-GDP gap. Larger banks may stabilize credit supply through diversified funding and economies of scale; nevertheless, their increased interconnectedness and propensity for riskier lending can exacerbate fluctuations in the credit cycle. Rapid loan expansion can also widen the credit-to-GDP gap, and sharp deleveraging during downturns can intensify financial instability.

According to Adusei and Elliot (2015), bank size has a positive effect on stability, suggesting that larger banks are less likely to fail. Larger banks may benefit from stronger capital buffers, greater diversification, and economies of scale and scope. Smaller banks seem to be more vulnerable. The findings indicate that growth or expansion can enhance the stability of smaller banks.

Evidence on the relationship between bank size and vulnerability is mixed. Pessarossi et al. (2020) find no substantial size influence on European bank fragility. IMF (2023) show that vulnerability changes by area, with smaller banks being weaker in emerging markets.

However, much of the literature finds a negative association between size and vulnerability. [Crosignani et al. \(2023\)](#) and [Jiang et al. \(2024\)](#) demonstrate that larger banks encounter fewer liquidity or solvency challenges, while the [IMF \(2025a\)](#) and [Adrian and Oura \(2023\)](#) similarly highlight enhanced resilience among substantial institutions. By contrast, [Belkhir et al. \(2023\)](#), [Vu and Katsiampa \(2025\)](#), and [Jung and Uhlig \(2019\)](#) say that larger banks are more likely to collapse and are more sensitive to changes in monetary policy, which is in line with the “too-big-to-fail” hypothesis.

Most studies find a significant negative association between bank capitalization, measured by the equity-to-assets ratio, and bank vulnerability. Collectively, this literature suggests that higher capital buffers are associated with greater resilience, lower distress and systemic risk, reduced liquidity stress and lower sensitivity to shocks ([Barajas et al., 2020](#); [Belkhir et al., 2023](#); [Crosignani et al., 2023](#); [IMF, 2025a, 2025b](#); [Jiang et al., 2024](#); [Kabundi & De Simone, 2019](#); [Pessarossi et al., 2020](#); [Soenen & Vander Vennet, 2021](#); [Vu & Katsiampa, 2025](#)). [Jung and Uhlig \(2019\)](#) demonstrate that higher equity ratios alleviate the detrimental effects of monetary policy shocks on bank stability. [Laeven and Levine \(2009\)](#) suggest that concentrated ownership may encourage risk-taking in well-capitalized banks. However, empirical data consistently demonstrates that strong capitalization substantially enhances banking stability.

In line with [Karim et al. \(2013\)](#) OBS operations undermine bank stability, as evidenced by their detrimental and considerable impact on the Z-score for both commercial and Islamic banks in the Middle East and North Africa. OBS exposures, including derivatives and contingent liabilities, are consequently associated with increased fragility. More evidence supports this view: [Kick and Prieto \(2015\)](#) demonstrate that elevated OBS-to-assets ratios substantially augment the distress probabilities of German banks; [Haq et al. \(2022\)](#) find that while OBS activity may reduce average risk, it significantly escalates tail risk for G7 banks, particularly post-2008; and [Papanikolaou and Wolff \(2014\)](#) illustrate that OBS leverage considerably heightens both individual and systemic risk. These studies collectively demonstrate that increased OBS activity heightens vulnerability by reallocating risk to extreme, infrequent shock events.

[Levieuge et al. \(2019\)](#) assert that banking competition often undermines financial stability when the Lerner Index reflects diminished market power. According to the competition–fragility hypothesis, greater competition increases credit volatility and widens the credit-to-GDP gap by encouraging riskier lending and irregular credit growth. The [IMF \(2025a\)](#) Positive macro-financial conditions can encourage higher risk-taking and an increase of financial vulnerabilities ([IMF, 2025a](#)). [Hamdaoui and Maktouf \(2020\)](#) assert that GDP development often enhances stability by diminishing the likelihood of crises; nevertheless, rapid growth may encourage excessive risk-taking and susceptibility when circumstances change. [Pessarossi et al. \(2020\)](#), [Barajas et al. \(2020\)](#), [Belkhir et al. \(2023\)](#), and [Kabundi and De Simone \(2019\)](#) provide further evidence of a statistically significant negative correlation between GDP growth and financial fragility. Thus, improved macroeconomic performance strengthens banking resilience by enhancing asset quality and solvency and reducing the transmission of monetary and financial shocks.

Inflation is a major cause of banking instability. [Hamdaoui and Maktouf \(2020\)](#) demonstrate that inflation volatility compromises risk assessment and amplifies credit risk exposure. [Barajas et al. \(2020\)](#), [Chavleishvili et al. \(2024\)](#), [Belkhir et al. \(2023\)](#), and [Bergant et al. \(2025\)](#) all find a statistically significant positive link: higher inflation increases the risk of default, adds stress to the system, and makes weak banks even weaker, especially when monetary policy is stricter. Conversely, [Pessarossi et al. \(2020\)](#) and [Kabundi and De Simone \(2019\)](#) find a negative correlation, arguing that inflation may temporarily enhance bank

balance sheets through improved nominal performance and stronger economic activity. Overall, the empirical evidence on inflation and banking vulnerability remains mixed.

The role of the real interest rate should also be understood in connection with the low-interest-rate environment that accompanies QE. It should be seen alongside the bank risk-taking channel discussed earlier. [Hamdaoui and Maktouf \(2020\)](#) provide evidence that low real rates stimulate credit booms, whereas increases in real rates raise default risk and weaken loan portfolios. Overall, the effect on banking instability is positive and statistically significant across countries. [Adrian and Oura \(2023\)](#) reach a similar conclusion: changes in the interest rate environment can generate valuation losses, increase provisioning needs, and make banks more vulnerable. This pattern is supported by recent empirical evidence: [Crosignani et al. \(2023\)](#) argue that the rapid interest rate increases of 2022 heightened systemic risk through unrealized losses and leverage. [Jiang et al. \(2024\)](#) show that higher rates reduce asset values, capitalization, and solvency, thereby increasing the risk of banking distress. [Chavleishvili et al. \(2024\)](#) demonstrate that front-loaded tightening substantially increases the Composite Indicator of Systemic Stress. [Belkhir et al. \(2023\)](#) find that higher policy rates increase systemic risk by worsening funding costs and credit quality. Conversely, [Kabundi and De Simone \(2019\)](#) identify a negative correlation, suggesting that persistently low rates may increase systemic risk by encouraging excessive risk-taking and leverage. The literature therefore indicates that both very low and rapidly rising interest rates can increase vulnerability: persistently low rates gradually increase risk-taking, whereas abrupt increases create more immediate systemic risks.¹

[Vu and Katsiampa \(2025\)](#) integrate money supply metrics (M1–M3) into their Synthetic Monetary Condition Index, demonstrating that monetary expansion elevates systemic risk, thereby validating a systemic risk-taking mechanism that exacerbates the susceptibility of Eurozone banks.

[Vu and Katsiampa \(2025\)](#) show how substantial Eurosystem asset purchases, used as a proxy for QE, markedly elevate systemic risk, particularly for smaller and undercapitalized banks, thereby underscoring the link to systemic risk-taking. By contrast, [Jung and Uhlig \(2019\)](#) state that the ECB's Asset Purchase Program improved bank conditions by steepening the yield curve and normalizing banks' responses to monetary policy.

Although numerous studies investigate the factors contributing to bank fragility, information regarding the impact of central bank transparency on bank vulnerability, particularly during QE, remains scarce. Unconventional policies make it harder to interpret market signals; therefore, transparency is important for setting expectations and managing risk-taking. [Jung and Uhlig \(2019\)](#) demonstrate that clearer communication from the ECB diminishes uncertainty and strengthens bank stability, whereas [Carvalho et al. \(2025\)](#) underscore that consistent communication enhances policy credibility and mitigates vulnerability by increasing market predictability.

More recently, a significant concern has been raised that more central bank transparency is not necessarily better. [Beretta et al. \(2026\)](#) question the assumption that more comprehensive communication is always better. They argue that in periods of deep uncertainty a certain amount of strategic uncertainty might be advantageous, as long as it does not cover up the bank's message or damage trust. That is, there is no secret cure; however, there may work better or worse depending on the content of what is released and the context within which policy is formed.

This moderating role is especially relevant when QE is in place and interest rates remain low for extended periods. Under these conditions, vulnerability usually develops gradually through increased risk-taking, higher leverage, and portfolio shifts toward riskier assets ([C. Borio & Zhu, 2012](#); [Brana et al., 2018](#)). When monetary policy is eventually tightened, these accumulated imbalances can appear as valuation losses, funding strains, and

deteriorating balance sheets (Crosignani et al., 2023; Jiang et al., 2024). Greater transparency can help banks and financial markets respond more smoothly to policy normalization by clarifying policy signals and allowing market participants to anticipate policy changes earlier. This can help prevent the banking sector from weakening too quickly (Carvalho et al., 2025; Jung & Uhlig, 2019).

3. Data and Methodology

This section outlines the data sources, key variables, and methodological approach used to examine the factors influencing bank vulnerability. The research focuses on exploring how shifts in these factors affect the vulnerability of banks.

3.1. Data

The review prioritized empirical studies investigating the interplay between monetary policy, macroeconomic conditions, central bank features, bank-specific traits, and bank vulnerability. Table 1 details the variables analyzed, including their definitions and data sources.

Table 1. Description of variables and their sources.

Variable	Definitions	Source
Vulnerability Variables		
$\Delta \ln(\text{Credit Volatility})$	Annual first difference of the natural logarithm of credit volatility. Credit volatility is calculated as an annualized five-year moving variance of quarterly credit data.	International Monetary Fund's International Financial Statistics (IFS) database.
Credit to GDP Gap	Credit to GDP Gap	Bank for International Settlements
Monetary Policy Indicators		
STR	Short Term Rate (overnight interest rate)	stlouisfred
M3	Money Supply	stlouisfred
QE	Quantitative Easing (percentage change in a central bank's balance sheet)	Central Banks
MPS	The annual Federal Reserve monetary policy shock	Bu, Rogers, and Wu; Wenbin Wu research database
TRNS	Central Bank Transparency	Dincer and Eichengreen (2014)
Macroeconomic Variables		
GDP	Real GDP Growth	World Bank
INF	Annual Inflation Rate	OECD
Industry Variables		
CONC	Concentration	World Bank
Bank Specific Variables		
SIZE	$\Delta \ln(\text{Total Assets})$	Bankscope
EA	Equity to Total Assets	Bankscope
OBS	Off Balance Sheet	Bankscope

The research is based on a comprehensive dataset comprising 233 banks from 8 economies across the European Union and North America, covering diverse banking systems. The data spans the period from 2013 to 2019, totaling 1330 observations. However, the final estimation samples are smaller because of missing values, lagged variables, and differences in data availability across specifications. The regressions therefore rely on complete-case observations, resulting in approximately 233 banks and between 1109 and

1330 observations, depending on the dependent variable and model specification. Table 2 offers a detailed overview of the distribution of banks by country and summarizes the essential features of the sample.

Table 2. Banks in sample by country.

Country	Number of Banks
Austria	26
Belgium	17
Denmark	21
Finland	9
France	53
Spain	32
Sweden	13
United States of America	62
Total	233

The data are obtained from internationally recognized sources to ensure cross-country consistency and comparability.

The dependent variable is bank vulnerability, which is measured by two complementing indicators: credit volatility and credit-to-GDP gap. Credit volatility is computed as the five-year moving variance (annualized) of quarterly credit data (credit to GDP ratio) from the IMF's International Financial Statistics database. The annual series is log-transformed, and we utilize its annual first difference, $\Delta \ln(\text{Credit Volatility})$, for the empirical parameters). Credit volatility, derived from the IMF's International Financial Statistics database (IMF, 2025c), captures fluctuations in lending activity and reflects short-term instability in banks' credit exposure. In contrast, the credit-to-GDP gap, as provided by the Bank for International Settlements (BIS, 2025), measures deviations of total credit from its long-term trend, thereby indicating potential credit booms or imbalances within the financial system. Together, these indicators provide a comprehensive perspective on systemic fragility, as both elevated volatility and persistent credit expansion may signal rising financial vulnerability.

Monetary policy indicator data are sourced from the Federal Reserve Economic Data (FRED) database, maintained by the Federal Reserve Bank of St. Louis and various central bank publications. The short-term interest rate (STR) denotes the overnight policy rate and encapsulates conventional monetary policy actions. The financial system's liquidity is measured by M3, while QE is quantified as the annual percentage change in each central bank's balance sheet, reflecting the degree of unconventional monetary expansion. The third model also incorporates the Federal Reserve monetary policy shock of Bu et al. (2021). The metric is designed to isolate surprises in the stance of U.S. monetary policy and to separate policy shocks from the information component of Federal Reserve pronouncements.

Three variables are included to capture the macroeconomic environment: real GDP growth rate (sourced from the World Bank) and the annual inflation rate (from the Organisation for Economic Co-operation and Development). These indicators account for business cycle dynamics, price stability, and fiscal conditions that may affect the overall stability of the banking sector.

The concentration variable in the banking sector (CONC), sourced from the World Bank, quantifies the proportion of total assets owned by the three largest banks within each country. This functions as an indicator of market concentration and competition in the domestic financial system.

The bank-specific variables are taken from Bankscope database. Total assets are expressed in thousands of Euros. Bank size is computed as the natural log of total assets at the initial period. The empirical specifications employ the first difference of bank size, $\Delta \ln(\text{Total Assets})$, which represents the annual change in bank size. The equity to total assets ratio indicates the level of capitalization and the capability to absorb losses, while the off-balance-sheet exposures measure non-traditional activities and contingent risks that may raise vulnerability.

Descriptive statistics and graphical analysis are used to summarize the dataset and highlight significant patterns across countries and years. Table A1 (Appendix A) presents the means and standard deviations for all variables used in the empirical analysis.

Table A1 shows the mean and standard deviation for the independent variables in the sample nations. There is considerable variation across economies, reflecting differences in banking systems and macro-financial situations. For instance, the United States represents an economy with larger banking sector (SIZE) and higher off-balance-sheet exposures (OBS). By contrast, Central Europe is characterized by smaller, more capital-conservative banking systems with higher equity ratios (EA).

Among the monetary policy indicators, QE values are highest in economies that made large-scale asset purchases (such as the United States). By contrast, negative STR values are observed in several euro area countries, reflecting their highly accommodative policy stances. Differences in central bank transparency indicate variation in the clarity and transparency of monetary policy communication. Macroeconomic indicators including inflation and gross domestic product (GDP) growth also show differences that match the cyclical patterns of each economy.

Appendix A complements the descriptive statistics with Figures A1–A3, which display the annual evolution of the main variables for the period 2013–2019. Credit volatility was declining from 2013 to 2016 and then increasing, while the credit-to-GDP gap peaked at its highest negative value in 2015 and was steadily decreasing to zero. The QE increased significantly between 2014 and 2016 and then decreased, consistent with the asset-purchase-program strategy reported in the official ECB announcements (Grosse-Rueschkamp et al., 2019). Central bank transparency increased and remained broadly stable after 2017, consistent with the reported steady movement toward greater central bank transparency over time (Dincer & Eichengreen, 2014). The QE–transparency interaction moves closely with the evolution of QE while the shock indicator changes a lot and becomes particularly negative in 2019. The large dispersion around the vulnerability indicators also implies that there is a considerable variation across the sample. These graphical patterns are descriptive, not causal, as the subsequent econometric analysis controls for bank-specific and macroeconomic factors, unobserved heterogeneity and differences across model specifications.

The red line represents the annual median, while the shaded regions cover the 25th to the 75th percentiles and provide further information about the cross-sectional dispersion of the variables around their annual median values. The interquartile range of credit volatility is quite wide across the study period, suggesting considerable heterogeneity across banks. It seems to narrow considerably towards the conclusion of the period. The credit-to-GDP gap also demonstrates quite a lot of dispersion, which increases after 2015, indicating more varied credit cycle conditions throughout the observations. By comparison, the interquartile range of QE shrinks considerably after 2017, as the indicator approaches zero for a bigger share of the sample. After 2017, transparency is also much less distributed, indicating a higher convergence in levels of transparency. Consistent with these characteristics, the spread of the QE–transparency relationship drops significantly in 2018 and 2019. Taken together, the shaded areas illustrate that the yearly median trends mask considerable cross-sectional variation, in particular for the two banking vulnerability indicators.

3.2. Methodology

This study adopts a quantitative methodology to examine how changes in monetary policy affect bank vulnerability. It uses econometric methods, specifically, a panel data framework, to quantify the association between monetary policy instruments and the vulnerability of banks to financial stress.

This research examines the correlation between monetary policy and the susceptibility of the banking sector, integrating novel aspects such as central bank transparency and the application of QE measures. The methodology framework uses the econometric frameworks established by [Levieuge et al. \(2019\)](#), modifying them for a cross-country panel. The analysis seeks to clarify the impact of monetary policy orientation, especially within unconventional frameworks, on the stability and resilience of banking institutions.

The baseline structure is similar to that used by [Levieuge et al. \(2019\)](#), who looked at how central bank conservatism affects systemic risk.

Panel data analysis is employed to simultaneously address both cross-sectional (inter-country) and time series (intra-country) variances in monetary policy and banking results. This dual dimension enhances estimate efficiency and alleviates omitted variable bias resulting from unobserved heterogeneity ([Baltagi, 2021](#)).

Given the dynamic nature of bank vulnerability and the potential endogeneity of the regressors, the main analysis employs the two-step System GMM estimator. This approach incorporates a lagged dependent variable, controls for unobserved bank-specific heterogeneity, and uses internal instruments to address endogeneity.

As a complementary model [Levieuge et al. \(2019\)](#) use panel regressions with fixed effects to account for unobservable country-specific factors that are linked with explanatory variables. In line with this methodology, the current investigation employs a fixed effects (FE) model to account for unobserved heterogeneity and ensure consistent parameter estimation. This substantiates that FE yields reliable and impartial estimates in this setting.

The FE estimator is especially suitable in this context, as numerous explanatory factors are likely to exhibit correlations with unobservable country-specific characteristics. Following [Levieuge et al. \(2019\)](#) using random effects (RE) would yield biased outcomes in the presence of such an association.

This method ensures consistency with other important research while also adding new elements, such as the relationship between transparency and QE. The model, like [Levieuge et al. \(2019\)](#), captures the trade-off between price stability and financial stability. The use of bank-specific and structural factors by [Demirgüç-Kunt and Detragiache \(1998\)](#) links the micro and macro levels of the analysis. The combination of these methods produces a balanced empirical framework that can distinguish the monetary and institutional factors that make banks vulnerable.

3.3. Model

We first standardized QE and central bank transparency, which we call QE^{std} and TRN^{std} , respectively, before running the main study. We then generated the interaction term by multiplying the two standardized variables. This step had a few practical purposes: it equalized the scale of the two variables, facilitated the interpretation of the interaction, and allowed the coefficients for the main effects to be interpreted as the effect when the other variable is at its average level.

For the main examination of determinants of bank vulnerability, we used the two-step System GMM estimator ([Arellano & Bover, 1995](#); [Blundell & Bond, 1998](#)). We take this strategy as our model includes a lagged dependent variable and several potentially endogenous regressors. This approach also allowed us to control for unobservable differences

among banks and for any common shocks over time. The equation for the baseline that we estimated is presented as follows:

$$Y_{i,j,t} = \alpha + \rho Y_{i,j,t-1} + \beta_1 QE^{std}_{j,t} + \beta_2 TRNS^{std}_{j,t} + \beta_3(QE^{std}_{j,t} \times M_{j,t}) + \sum_{k=1}^K \gamma_k X_{k,i,j,t} + \varepsilon_{i,j,t}$$

where i denotes the bank, j the country, and t the year. The dependent variable $Y_{j,t}$ measures bank vulnerability proxied by credit volatility (CV) and the credit-to-GDP gap, $Y_{j,t-1}$ captures its persistence, QE denotes quantitative easing, $TRNS$ denotes central bank transparency, and $X_{k,i,j,t}$ represents the vector of bank-specific, monetary policy, central bank, macroeconomic, and market structure control variables. The term $\varepsilon_{i,j,t}$ denotes the error term.

$M_{j,t}$ denotes the annual change in standardized central bank transparency, $\Delta TRNS^{std}_{j,t}$, when credit volatility is the dependent variable, and the level of standardized transparency, $TRNS^{std}_{j,t}$, when the credit-to-GDP gap is examined.

To complement the baseline dynamic analysis, two additional static fixed-effects models are estimated. The first corresponds to the baseline model without the lagged dependent variable:

$$Y_{i,j,t} = \alpha + \beta_1 QE^{std}_{j,t} + \beta_2 M_{j,t} + \beta_3(QE^{std}_{j,t} \times M_{j,t}) + \sum_{k=1}^K \gamma_k X_{k,i,j,t} + \varepsilon_{i,j,t}$$

while the second extends the static model by incorporating lagged monetary policy shocks $LMPS_{j,t-1}$:

$$Y_{i,j,t} = \alpha + \beta_1 QE^{std}_{j,t} + \beta_2 M_{j,t} + \beta_3(QE_{j,t} \times M_{j,t}) + \beta_4 LMPS_{j,t-1} + \sum_{k=1}^K \gamma_k X_{k,i,j,t} + \varepsilon_{i,j,t}$$

As a supplementary robustness check, the fixed-effects models are re-estimated using Driscoll–Kraay standard errors with a maximum lag of one. This addresses potential heteroskedasticity, serial correlation, and cross-sectional dependence among banks exposed to common national and monetary conditions. Because the panel has a short time dimension, the results are interpreted as sensitivity evidence rather than as a separate primary estimation framework.

To investigate whether the aggregate transparency index masks heterogeneous effects, an additional component-level analysis disaggregates the index into its five constituent dimensions: political, economic, procedural, policy, and operational transparency. Each standardized dimension is entered separately into the fixed-effects interaction specifications, within each dependent variable. Consistent with the main specifications, annual changes in the standardized dimensions are used in the credit volatility models, whereas standardized levels are used in the credit-to-GDP gap models. The corresponding models are also estimated with lagged monetary-policy shocks.

In models with an interaction term, the coefficients on QE^{std} and the transparency moderator are conditional effects. Specifically, β_1 measures the effect of QE^{std} when the transparency moderator is zero and β_2 measures the effect of transparency when QE^{std} is zero. Hence the conditional marginal effect of QE^{std} is given by

$$\frac{\partial Y_{i,j,t}}{\partial QE^{std}_{j,t}} = \beta_1 + \beta_3 M_{j,t}$$

Accordingly, the interaction coefficient β_3 indicates how the marginal effect of QE^{std} changes as central bank transparency changes. The conditional effects are evaluated at representative observed values of the transparency moderator and are reported together with 95% confidence intervals.

The comparison of the dynamic and static specifications allows us to evaluate whether the estimated relationships remain consistent across alternative econometric approaches.

Several indicators are needed to assess banking sector vulnerability because each captures a different aspect of financial instability. C. Borio et al. (2014) and the IMF (2025a) both stress that using a mix of complementary vulnerability metrics makes empirical results more reliable by showing both cyclical and structural features of financial fragility. This multidimensional approach facilitates a more thorough comprehension of the collective impact of monetary policy, financial structure, and macroeconomic conditions on the resilience of the banking system. This analysis uses two principal metrics: credit volatility and the credit-to-GDP gap, both of which are widely recognized in the literature as important indicators of banking sector susceptibility and precursors of financial difficulties.

The credit-to-GDP gap measures how far the ratio of credit to the private non-financial sector deviates from its long-term trend. The Bank for International Settlements (C. Borio et al., 2014) indicates that this measure captures excessive credit expansion compared to economic production. It is a leading indicator of systemic risk and financial overheating. C. Borio (2014) and Drehmann and Juselius (2014) assert that enduring positive gaps signify credit booms that frequently precede financial crises, whereas negative gaps represent deleveraging phases commonly linked to economic recessions. Thus, the metric shows how macroeconomic changes can affect the fragility of bank balance sheets, which is a sign of cyclical weaknesses in the financial system. According to the ECB (2022), the credit-to-GDP gap is still an important factor in countercyclical capital buffer regimes and is necessary for monitoring macroprudential risks in advanced economies.

Credit volatility is initially calculated at the quarterly frequency as the five-quarter rolling population variance of bank credit as a percentage of GDP. The quarterly volatility series is subsequently converted to annual frequency by retaining the fourth-quarter observation of each year. The natural logarithm of this annual measure is then calculated, and the dependent variable used in the estimations is its annual first difference:

$$\Delta \ln(CV_{j,t}) = \ln(CV_{j,Q4,t}) - \ln(CV_{j,Q4,t-1})$$

Positive values indicate an increase in credit volatility relative to the preceding year, whereas negative values indicate a decline.

The resulting measure captures short-term changes in the instability of credit provision Aikman et al. (2019) and Carvalho et al. (2025) stress that excessive credit volatility increases systemic risk by causing rapid drops in lending, lower asset quality, and mismatches in liquidity. High credit volatility often indicates that banks' risk management policies are not in line with the state of the economy, which can cause sudden credit cycles and instability in funding markets. By contrast, decreased volatility means that loan intermediation is smoother and financial links are stronger, both of which are important for overall financial stability. Friedrich et al. (2019) say that credit volatility is a dynamic indicator that shows how sensitive bank balance sheets are to changes in monetary and financial conditions over a short period of time. This is relevant when assessing the effects of unconventional monetary policies like QE.

The fixed-effects specifications use the annual change in standardized transparency, $\Delta \text{TRNS}^{\text{std}}$, to analyze whether the year-to-year changes in central bank communication change the immediate effect of QE on credit instability, as credit volatility captures the short-term volatility of credit provision. Standardized transparency enters in levels in the credit-to-GDP gap specifications, in contrast, as this metric captures broader and more persistent imbalances in the credit cycle. This distinction matches the temporal shape of the transparency variable with the particular dimension of vulnerability recorded by each dependent variable. This short-run definition is theoretically consistent with research on

monetary transmission that analyzes the effects of policy through changes in important policy variables (Gambacorta & Marques-Ibanez, 2011).

The credit-to-GDP gap and credit volatility are two variables that work together to provide a fuller picture of banking sector vulnerability. The first measure captures long-term cyclical imbalances, and the second indicator captures short-term credit instability. Using these measures allows closer analysis at how monetary policy transmission, especially through QE and transparency, affects not just the size but also the variability of bank credit dynamics. This two-measure approach is in line with the ECB's (2022) and IMF's (2025a) suggestions for multidimensional frameworks for analyzing financial stability. This accounts for both cyclical and time-varying aspects of vulnerability.

The empirical model integrates bank-specific, structural, macroeconomic, monetary, and institutional factors frequently used in the banking vulnerability literature. This multidimensional framework facilitates the identification of both micro-level risk variables and macro-financial transmission mechanisms.

At the bank level, vulnerability is evaluated using the annual change in bank size, measured by $\Delta \ln(\text{Total Assets})$, capitalization measured by the equity-to-assets ratio (EA), and off-balance-sheet activities (OBS). Changes in bank size capture balance sheet expansion or contraction, while capitalization reflects the bank's capacity to absorb losses (Smith et al., 2017; Nguyen et al., 2023) and OBS exposures show risks that could amplify vulnerabilities if they are not handled properly.

Bank concentration (CONC) captures competition and market power in the banking sector, thereby accounting for market structure. A higher concentration may influence lending practices, pricing, and the dissemination of monetary policy, impacting both stability and risk-taking (Gödl-Hanisch, 2022; Saidi & Streitz, 2021).

Real GDP growth (GDP) and inflation rate are all measures of overall economic conditions. These factors capture business cycle dynamics and price stability that affect bank resilience. Strong economic growth usually improves asset quality, but inflation volatility and high sovereign debt can weaken bank balance sheets through credit risk, funding costs, and feedback loops between sovereign debt and banks (Patel, 2024).

The STR, M3, and QE are all measures of monetary policy. Interest rates influence borrowing costs and risk-taking incentives, whereas money supply reflects liquidity conditions. QE, as shown by changes in central bank balance sheets, signifies unconventional monetary accommodation that could influence banks' portfolio choices, leverage, and susceptibility to future shocks (Adrian et al., 2025; Demirgüç-Kunt & Detragiache, 2002).

Central bank transparency captures the extent to which a central bank shares information about its policy framework, goals, decision-making processes, and operations with the public. The ECB says that clear and timely information improves public understanding and policy credibility. The IMF (2025b), in turn, says that transparency is a multi-dimensional institutional practice that makes policies more accountable and effective. Transparency helps stabilize expectations, lower uncertainty, and facilitate monetary transmission by making clear the central bank's policy stance and future plans. This is especially important during times of financial crisis and when central banks use unconventional policies like QE.

4. Empirical Results

This section presents the empirical findings on how monetary policy affects bank vulnerability. The analysis is based on a dataset of banks from 8 countries between 2013 and 2019. Because bank vulnerability tends to persist over time, and because monetary policy, bank behavior, and financial fragility may influence one another, a dynamic panel model was selected as the main empirical approach. This model helps account for how

vulnerability adjusts slowly over time and helps determine whether QE, central bank transparency, and their interaction remain significant once we factor in that persistence.

The main results come from that dynamic panel model. The consistency of these findings was confirmed using two fixed-effects models. The first measure includes the interaction term between QE and central bank transparency. The second one adds lagged annual monetary shocks. This setup shows whether the main dynamic results still hold when we use alternative static models and when we control for delayed monetary disturbances.

It is necessary to distinguish between the direct effects of monetary policy on bank vulnerability and the effects that operate through central bank transparency. Special attention was given to the interaction between QE and transparency, because that term shows whether clearer communication from central banks makes unconventional monetary expansion more or less risky for banks.

Because the specifications include an interaction between QE^{std} and transparency, the reported main-effect coefficients are conditional. The coefficient on QE^{std} represents its effect when standardized transparency equals zero, while the interaction coefficient indicates how this effect changes as transparency increases. The interaction is therefore interpreted through conditional marginal effects rather than from its coefficient alone.

Table 3 presents the baseline two-step System GMM estimates for the two measures of bank vulnerability.

Table 3. Vulnerability Measures and Monetary Policy. Two-step system GMM estimates, baseline results.

Dependent Variables	(1)			(2)		
	Credit Volatility			Credit to GDP Gap		
	Coeff.		Std. Error	Coeff.		Std. Error
$\Upsilon_{i,j,t-1}$	0.30251	**	0.096326	0.61994	***	0.19019
QE^{std}	0.78072	***	0.02193	1.62255	**	0.58665
$TRNS^{std}$	−0.93716	***	0.20490	−4.38861	*	2.24558
$QE^{std} \times TRNS^{std}$	−0.25183	***	0.06279	−2.02121	**	0.86408
$\Delta \ln(\text{Total Assets})$	0.00445		0.01421	−0.10260		0.22839
EA	−0.01970		0.05737	−2.02486		1.98570
Ln_OBS	0.00819	**	0.00370	0.05779		0.09936
CONC	0.00265	***	0.00054	0.16601	**	0.07442
GDP	0.15845	**	0.05860	−0.14433		0.44748
INF	0.02630		0.01758	−0.41907		0.33336
STR_Overnight	0.02665		0.01695	0.53243		0.49230
M3	0.00761		0.00545	0.27644		0.30968
Number of observations	1109			1109		
Number of banks	233			233		
Average number of observations per group	4.76			4.76		
Number of instruments	14			14		
AR1	0.000			0.001		
AR2	0.449			0.749		
Sargan test (<i>p</i> -value)	0.565			0.539		
Hansen	0.483			0.404		

* $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$ denote statistical significance. Note: QE^{std} denotes standardized quantitative easing. In the credit volatility specification, the transparency moderator is the annual change in standardized transparency ($\Delta TRNS^{std}$), and the interaction term is $QE^{std} \times \Delta TRNS^{std}$. In the credit-to-GDP gap specification, the moderator enters in levels ($TRNS$), and the interaction term is $QE^{std} \times TRNS^{std}$.

The positive coefficient on QE^{std} indicates that QE is positively associated with vulnerability when standardized transparency is at its mean value, $TRNS = 0$. This provides evidence of the continuing link between accommodative monetary policy and increasing risk-taking by banks. This finding is consistent with the risk-taking channel in [C. Borio and Zhu \(2012\)](#), which suggests that in prolonged accommodative monetary environments, financial institutions tend to take more risk and extend more credit. The conclusion is also consistent with recent evidence that prolonged monetary accommodation can over time increase financial vulnerabilities and balance sheet pressures in the banking sector ([Chavleishvili et al., 2024](#); [Jiang et al., 2024](#)). The positive coefficient on QE in the model with the credit-to-GDP gap further suggests that ongoing accommodation may cause medium-term credit imbalances, in line with the findings of [Dell’Ariccia et al. \(2018\)](#).

When STR is considered in the credit volatility model, the overnight rate is positive but not statistically significant. This indicates that there is no clear evidence that tighter monetary policy, as reflected in higher interest rates, reduces short-term credit risk, after controlling for persistence and endogeneity. One reading of this is that the interest rate channel may not be uniformly effective in dampening short-term credit fluctuations, whereas such a clear effect is observed for other vulnerability measures, this finding complements the interest rate channel of financial vulnerability discussed in the recent literature ([Chavleishvili et al., 2024](#); [Jiang et al., 2024](#)), yet our dynamic model suggests that the effect is not homogeneous across all types of vulnerability. Similarly, in the credit-to-GDP gap model, the effect on short-term interest rates is not statistically significant ([Londono et al., 2021](#)). This shows that adjusting short-term rates up or down does not seem to have as much of an effect on medium-term credit imbalances, unlike unconventional tools such as QE, which do matter.

In the System GMM estimates, M3 has a positive but statistically insignificant coefficient for both vulnerability indicators. Therefore, the dynamic specifications provide no clear evidence of an independent association between broad money and banking system vulnerability.

At the 1% level, central bank transparency has a consistently negative and statistically significant effect on both vulnerability metrics across all models. These findings illustrate that increased transparency diminishes banking fragility by alleviating uncertainty, improving market expectations, and bolstering the credibility of monetary policy frameworks ([Carvalho et al., 2025](#); [Jung & Uhlig, 2019](#)).

The strong negative relationship is important. It suggests that clear communication can dampen the risk-taking incentives associated with unconventional monetary easing. When a central bank is transparent about its goals, the information gap between policymakers and markets decreases. This can discourage the kind of risky investments that often make credit markets more unstable. In this sense, transparency seems to play a stabilizing role, and that role becomes especially visible when central banks are actively intervening ([Dincer & Eichengreen, 2014](#)). The effect of transparency remains negative and statistically significant when the model accounts for macroeconomic and structural factors. This kind of robustness suggests that transparency is not merely a cyclical phenomenon that matters only under particular economic conditions. Instead, it appears to function as a deeper institutional feature built into the way monetary policy is transmitted. This supports the view that central bank communication plays a substantive role in shaping financial stability.

Overall, these results support the view that transparent central banks can help set expectations and stabilize the banking system, especially when monetary policy is unconventional and communication is an important factor.

Among the bank-level variables, OBS shows the most relevant effect in the dynamic model, while SIZE is not consistently significant across specifications.

In the credit volatility model, OBS has a positive and statistically significant coefficient, suggesting that off-balance-sheet activities are associated with higher short-term fluctuations in credit conditions. This may indicate that such activities introduce additional complexity and risk in managing exposures and liquidity, thereby contributing to more volatile credit dynamics. By contrast, SIZE does not exert a statistically significant effect on credit volatility. Although the literature links bank size to financial stability through diversification, funding advantages, and risk-taking incentives (Belkhir et al., 2023; Vu & Katsiampa, 2025), these effects do not emerge strongly in this specification.

In the credit-to-GDP gap model, neither SIZE nor OBS is statistically significant. This suggests that bank-level characteristics play a more limited role in explaining medium-term credit imbalances once persistence, endogeneity, and broader macro-financial conditions are taken into account. Previous studies have emphasized the importance of bank size, balance sheet structure, and off-balance-sheet exposures for financial stability (Crosignani et al., 2023; Levieuge et al., 2019; Jiang et al., 2024; Kick & Prieto, 2015; Papanikolaou & Wolff, 2014). However, in the present dynamic specification, these channels appear to be more relevant for short-term credit volatility than for the credit-to-GDP gap.

Capital adequacy does not show consistent statistical significance in this model. The lack of a strong relationship may stem from differences in regulatory regimes across countries or from the inclusion of macroprudential controls that absorb part of the capital adequacy effect. Nonetheless, the sign of the coefficient is generally consistent with theoretical expectations that better-capitalized banks are more resilient, but this effect may be masked when other factors such as transparency or monetary policy dominate the explanatory power of the model.

The macroeconomic environment significantly influences the susceptibility of the banking sector. The model included two key variables: real GDP growth and inflation rate. Each of these variables captures a different aspect of macroeconomic stability.

In the credit volatility model, the coefficient of GDP remains positive and statistically significant, showing that an increase in economic activity may be correlated with greater short-term variation in credit conditions. A possible explanation is that economic expansion leads to more risky lending behavior and greater credit dynamics, which in turn increase short-run procyclicality in financial markets. This finding is in line with the earlier findings that economic growth may temporarily increase credit expansion and risk-taking behavior, especially in an environment of supportive monetary conditions (Belkhir et al., 2023; Hamdaoui & Maktouf, 2020). By contrast, the coefficient of GDP in the credit-to-GDP gap specification is negative but statistically insignificant in the dynamic model. Nevertheless, the estimated direction is broadly consistent with the view that stronger economic growth may help align credit expansion more closely with underlying economic fundamentals, thereby limiting excessive deviations from the long-run trend. In sum, the results imply a relatively stronger effect of GDP growth on the short-term credit dynamics than on the medium-term structural imbalances in the dynamic setting.

Inflation exhibits the same effect across the two dynamic specifications. In the credit volatility model, the coefficient is positive but statistically insignificant. This result may indicate that inflationary dynamics alone are insufficient to explain short-run fluctuations in banking vulnerability once broader monetary and macro-financial conditions are taken into account. By contrast, inflation displays a negative but statistically insignificant effect on the credit-to-GDP gap specification. This finding suggests that rising price pressures do not significantly influence the accumulation of medium-term credit imbalances within the dynamic framework. One possible interpretation is that inflationary environments may coincide with accommodative financial conditions and stronger credit expansion dynamics, particularly when monetary policy remains supportive. This interpretation is broadly

consistent with the argument of C. E. Borio and Lowe (2002), who contend that financial imbalances may continue to build even under relatively stable inflation conditions when monetary accommodation persists. Similarly, Detken and Smets (2004) argue that inflation often remains comparatively stable during periods of credit and asset price booms, limiting its effectiveness as an early indicator of financial instability. However, the findings differ from those of Kabundi and De Simone (2019), who suggest that moderate inflation may alleviate real debt burdens and reduce excessive credit pressures. Overall, the dynamic estimates indicate that the relationship between inflation and banking vulnerability is likely to depend on broader monetary and financial conditions, rather than on inflation, a conclusion that remains consistent with the cited literature, given that the statistical insignificance of inflation in the credit-to-GDP gap model does not contradict C. E. Borio and Lowe (2002) or Detken and Smets (2004), who emphasize the role of broader financial conditions over inflation alone.

Overall, the macroeconomic results show that favorable macroeconomic conditions can strengthen structural resilience, whereas fiscal imbalances and growth-driven credit may intensify cyclical vulnerabilities. The direction and size of these effects depend substantially on the credibility of monetary policy and the frameworks of institutions.

The variable that measures banking concentration (CONC) has different effects on the two models. Concentration seems to have a positive and statistically significant effect on credit volatility and credit-to-GDP gap. This suggests that when there are fewer major, dominating institutions in the market, the credit-to-GDP gap tends to increase. This means that highly concentrated financial systems are more likely to have cyclical credit expansion. These results align with the studies by Levieuge et al. (2019) and Yuanita (2019), indicating that restricted competition can augment systemic interconnectivity and transmission effects. In essence, concentrated banking arrangements may heighten systemic vulnerability, not alone via instability in loan flows (credit volatility), but through extended credit deviations from equilibrium levels, as dominating institutions have greater impact on aggregate credit dynamics. This conclusion highlights the importance of market structure in assessing bank vulnerability. It supports earlier evidence that structural concentration can facilitate the transmission of financial shocks across large institutions.

4.1. Fixed-Effects Estimates

Additional models were estimated to complement the baseline dynamic-panel results. These additional models tested whether the main relations found in the dynamic model were consistent across alternative fixed-effects models and additional monetary conditions. The complementary fixed-effects analysis includes two main extensions: (i) the estimation of a fixed-effects model with the interaction term between QE and central bank transparency, (ii) the estimation of an extended fixed effects model by adding lagged annual monetary shocks (l.shocks) as an explanatory variable. Of particular interest is the connection between QE and transparency, as this term reflects whether central bank communication has a moderating role on the effect of unconventional monetary policy on banking sector vulnerability. Including lagged monetary shocks also allows the study to account for delayed monetary shocks and spillover effects that may impact financial conditions over time. These alternative models are jointly used to check the stability of the estimated coefficients and to test whether the primary conclusions of the dynamic model remain the same under various empirical models.

4.2. Interaction Between Quantitative Easing and Transparency

The first static fixed-effects model adds an interaction term ($QE \times$ central bank transparency) on a fixed-effects model to see if the effect of QE on bank vulnerability changes

depending on how transparent the central bank is. This model captures possible conditional effects by examining whether transparency amplifies, attenuates, or has no effect on the relationship between QE and credit market dynamics.

Table 4 also reports Country Cluster, Country Year, equal, and Country Year, Asset models to address within-country dependence and repeated country-year observations. The first clusters standard errors by country, while the latter two use simple and lagged-asset-weighted country-year averages. The negative QE–TRNS interaction remains across all models, suggesting that repeated country-year observations do not drive the result.

The conditional marginal effects are given by $\beta_1 + \beta_3 M$ and reported in Figures 1 and 2 and Table A2, Panel A, provide a more precise interpretation of the interaction. For credit volatility, the marginal effect of QE^{std} declines from 0.114 when $\Delta TRNS^{std} = -0.815$, to 0.022 when transparency remains unchanged, and becomes negative, -0.024 , when $\Delta TRNS^{std} = 0.407$. All three effects are statistically significant at the 1% level. For the credit-to-GDP gap, the marginal effect similarly declines as transparency increases: it falls from 4.856 at $TRNS^{std} = -2.899$ to 0.071 around $TRNS^{std} = -0.048$, where it is not statistically significant at the 5% level, and becomes -3.740 at $TRNS^{std} = 2.396$. These findings indicate that greater transparency progressively attenuates the positive association between QE and banking vulnerability and may reverse its sign at sufficiently high transparency values.

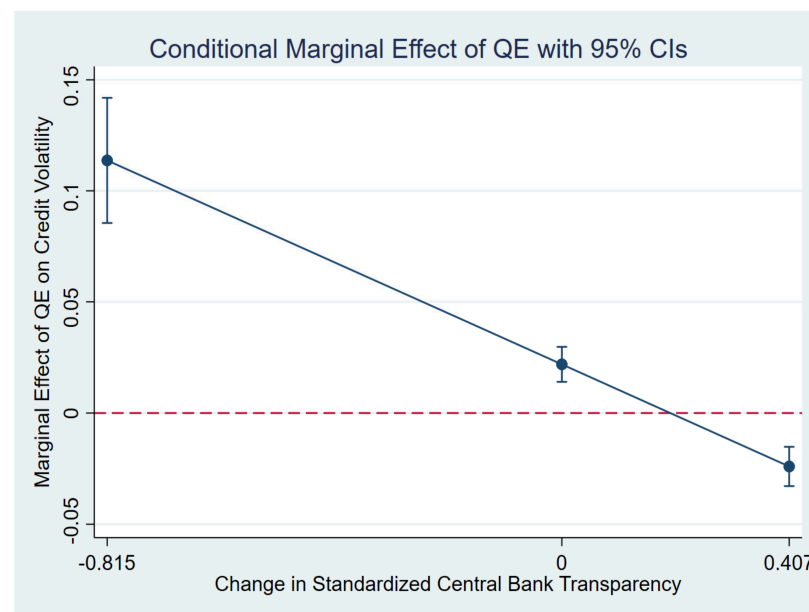


Figure 1. Conditional marginal effects of standardized QE on Credit Volatility. Note: The red dotted line indicates the zero-reference line.

Figures 1 and 2 present these conditional marginal effects and their 95% confidence intervals.

The findings are also in line with the expectations channel of monetary policy suggested by Woodford (2004) and the wider transparency literature which highlights the need for transparency in order to increase credibility and improve the effectiveness of monetary policy (Dincer & Eichengreen, 2014). Earlier work also implies that central bank communication can have a large effect on financial market movements and the risk-taking behavior of financial institutions (Jung & Uhlig, 2019). Better communication from monetary authorities can lead to more stable expectations about future policy conditions by banks and market players. As uncertainty falls, incentives for excessive risk-taking caused by imprecise policy signals may also fall. Transparency may therefore help to counteract the destabilizing impacts of expansionary unconventional monetary policy.

Table 4. Central Bank Transparency, QE and banking sector vulnerability: results obtained with the credit volatility and the credit-to-GDP gap—interaction term $QE \times TRNS$. Fixed Effects.

Dependent Variables	Credit Volatility					Credit-to-GDP Gap				
	Fixed Effects		Country Cluster	Country Year, Equal	Country Year, Asset	Fixed Effects		Country Cluster	Country Year, Equal	Country Year, Asset
	Coeff.	Std. Error	Coeff.	Coeff.	Coeff.	Coeff.	Std. Error	Coeff.	Coeff.	Coeff.
QE^{std}	0.02188 **	0.00401	0.021	0.031	0.026	0.14918 ***	0.04030	0.149	0.229	0.168
$TRNS^{std}$	−0.07760 ***	0.01080	−0.077	−0.054	−0.031	−0.78062 ***	0.14007	−0.780	−0.603	−1.230
$QE^{std} \times TRNS^{std}$	−0.11270 ***	0.01414	−0.112 *	−0.104 **	−0.057	−1.62321 ***	0.09802	−1.623	−1.938 *	−1.988 *
STRovernight	0.11961 ***	0.00438	0.119 ***	0.091	0.096 *	−0.64712 ***	0.05847	−0.647 **	−0.965 **	−0.370
M3	−0.00176 **	0.00074	−0.001	−0.001	−0.001	0.11160 ***	0.01275	0.111	0.162	0.165
CONC	0.00015	0.00026	0.000	0.001	0.000	0.01818 ***	0.00346	0.018	0.001	−0.015
$\Delta \ln(\text{Total Assets})$	0.00731	0.00928	0.007	−0.179	−0.211	0.00116	0.12105	0.001	2.076	2.468
EA	0.09169 **	0.04375	0.091	−1.005	−1.905	1.24605 **	0.56996	1.246 *	23.903	18.180
OBS	0.00866 **	0.00321	0.008	−0.005	0.069 *	0.14551 ***	0.04170	0.145	1.621 *	2.248 ***
GDP	−0.00570 **	0.00271	−0.005	−0.001	−0.006	−0.41993 ***	0.04251	−0.419 **	−0.313	−0.591 *
INF	0.01337 ***	0.00256	0.013	0.017	0.020	0.38710 ***	0.04170	0.387	0.570 *	0.399
Constant	−0.17107 ***	0.05034	−0.171	0.110	−1.079	−3.40198 ***	0.68448	−3.401	−22.492	−39.158 ***
Observations	1.330		1.330	46	46	1.330		1.330	46	46
R-squared	0.5523		0.5523			0.3706		0.3706		
Number of banks	233		233			233		233		

* Statistical significance at the 10% level ** Statistical significance at the 5% level *** Statistical significance at the 1% level. Note: QE^{std} denotes standardized quantitative easing. In the credit volatility specification, the transparency moderator is the annual change in standardized transparency ($\Delta TRNS^{std}$), and the interaction term is $QE^{std} \times \Delta TRNS^{std}$. In the credit-to-GDP gap specification, the moderator enters in levels (TRNS), and the interaction term is $QE^{std} \times TRNS^{std}$.

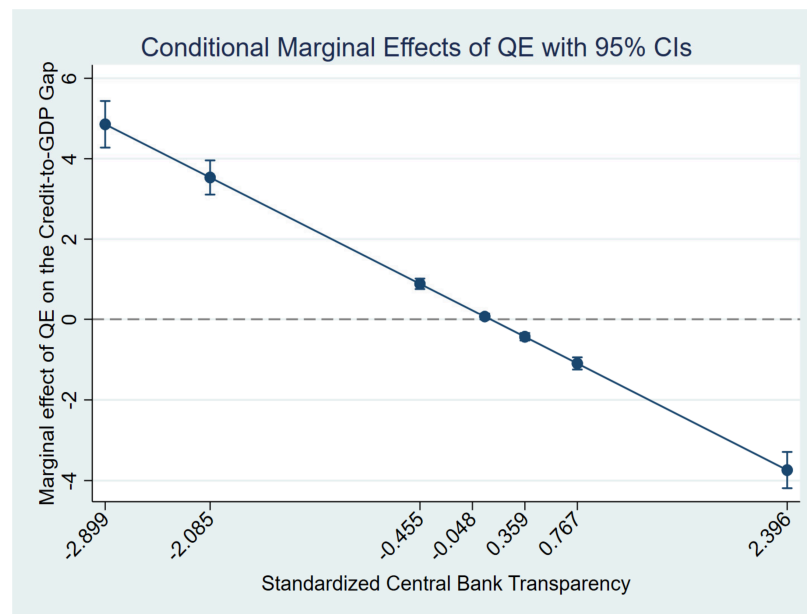


Figure 2. Conditional marginal effects of standardized QE on CredittoGDPgap. Note: The grey dotted line indicates the zero-reference line.

Transparency itself remains statistically significant in both models when the interaction term is included, unlike in the baseline specification. This means that transparency has its own stabilizing influence on banking vulnerability, apart from its moderating effect on the QE vulnerability link. The conclusion thus suggests that transparency matters to financial stability directly and indirectly, particularly during periods of unconventional monetary policy measures.

The remaining control variables likewise show economically important effects. In the credit volatility specification, coefficients of STR and inflation remain positive and statistically significant, indicating that tighter monetary conditions and inflationary pressures may increase short-run instability in credit markets. Positive but not statistically significant effects are found for CONC and SIZE. M3 is negative and statistically significant, indicating an inverse association with short-term credit volatility. OBS activities are found to be positive and statistically significant, which is consistent with the view that non-traditional banking exposures can increase financial fragility (Kick & Prieto, 2015; Papanikolaou & Wolff, 2014).

In the credit-to-GDP gap specification, banking concentration, inflation, and M3 are positive and statistically significant, indicating that liquidity conditions, macroeconomic pressures and market structure contribute to the build-up of medium-term credit imbalances. By contrast, the coefficients of GDP growth and short-term interest rates are negative and statistically significant, which suggests that stronger economic conditions, along with a stricter conventional monetary policy, may curb the excess credit growth compared to economic activity.

Overall, the inclusion of the interaction term significantly supports the primary empirical findings and provides further evidence on the relevance of transparency in the monetary policy transmission mechanism. The results consistently show that transparency moderates the QE and banking vulnerability link, supporting the claim that communication and policy credibility are important stabilizing mechanisms in times of unconventional monetary policy.

4.3. Incorporating Lagged Annual Federal Reserve Monetary Policy Shock

A second additional specification examines whether the baseline associations remain stable when the model includes lagged annual monetary shocks (l.shocks). This formulation seeks to clarify the persistence of monetary shocks over time and to determine whether the lagged impacts of monetary surprises modify the transmission of policy actions to banking vulnerabilities.

Adding lagged shocks is another way to examine model robustness, because it accounts for unexpected changes in policy that could change how banks act beyond changes in QE or interest rates simultaneously.

The Lucas critique (Lucas, 1976) posits that the parameters of an econometric model derived from historical data may change following a change in the policy regime, as economic agents adjust their expectations and behavior in reaction to new monetary frameworks. In this context, the relationship between monetary policy and banking vulnerability may change with different regimes, especially when central banks use unconventional tools like QE or become more transparent about their policies. These changes can change how policy signals are understood and sent through the financial system. The fixed-effects model aids in managing unobserved variation across countries and temporal dimensions; nonetheless, the Lucas critique posits that policy-induced behavioral modifications may still influence the estimated connections. The addition of the lagged U.S. monetary shocks variable provides an additional model that also addresses this critique, as it identifies potential spillover effects and assesses the stability of the calculated coefficients in varying policy contexts.

Table 5 presents the second complementary specification, which adds lagged annual monetary shocks and the interaction term between QE and central bank transparency to the fixed-effects model. The results are generally consistent with the baseline dynamic model and with the previous complementary model, supporting the stability of the main empirical relationships across alternative estimation approaches.

The inclusion of lagged monetary policy shocks does not materially alter the marginal-effect profiles, while the negative QE–transparency interaction remains consistent across specifications. Full estimates are reported in Table A2, Panel B, and Figures 3 and 4 in the Appendix A.

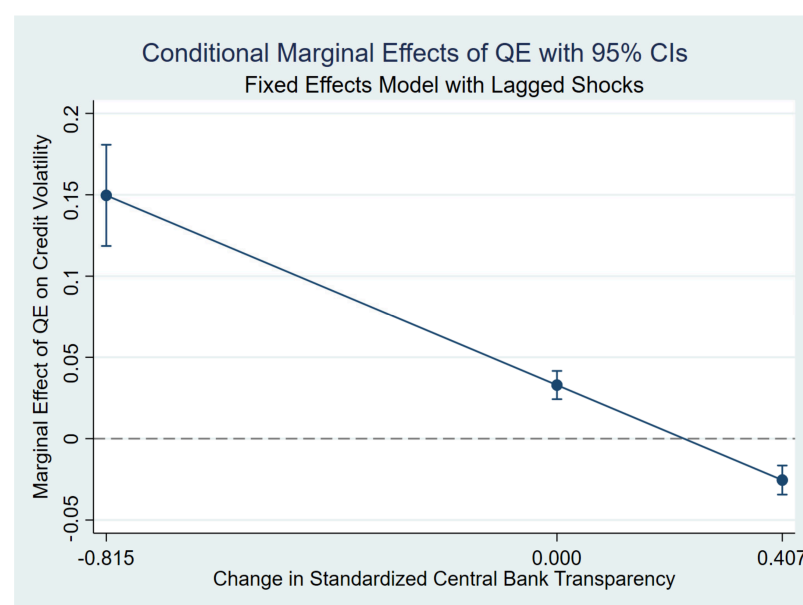


Figure 3. Conditional marginal effects of standardized QE on Credit Volatility with Lagged Monetary-policy Shocks. Note: The grey dotted line indicates the zero-reference line.

Table 5. Central Bank Transparency, QE and banking sector vulnerability: Results from the Static Fixed-Effects Model with Lagged annual Federal Reserve monetary policy shock.

Dependent Variables	Credit Volatility					Credit-to-GDP Gap				
	Fixed Effects		Country Cluster	Country Year, Equal	Country Year, Asset	Fixed Effects		Country Cluster	Country Year, Equal	Country Year, Asset
	Coeff.	Std. Error	Coeff.	Coeff.	Coeff.	Coeff.	Std. Error	Coeff.	Coeff.	Coeff.
QE ^{std}	0.03292 ***	0.00443	0.032 *	0.033 *	0.029	0.16000 ***	0.04207	0.016	0.229	0.171
TRNS ^{std}	−0.07728 ***	0.01099	−0.077	−0.049	−0.028	−0.82016 ***	0.14614	−0.820	−0.612	−1.075
QE ^{std} × TRNS ^{std}	−0.14328 ***	0.01534	−0.143 **	−0.107 **	−0.068	−1.57054 ***	0.10600	−1.570	−1.881	−2.030 *
STRovernight	0.10184 ***	0.00495	0.101 ***	0.075	0.078	−0.70900 ***	0.06896	−0.709 **	−1.086 **	−0.462
M3	−0.00275 ***	0.00081	−0.002	−0.001	−0.001	0.11031 ***	.01404	0.110	0.158	0.134
CONC	0.00015	0.00026	0.000	0.001	0.000	0.01848 ***	0.00368	0.018	0.001	−0.021
SIZE	0.01913 **	0.00952	0.019	−0.080	−0.171	0.04106	0.12738	0.041	2.513	1.878
EA	0.06259	0.04417	0.062	−1.128	−2.087	1.20296 **	0.58978	1.202	−24.375	15.795
OBS	0.00418	0.00332	0.004	−0.019	0.062 *	0.13836 **	0.04412	0.138	1.554 *	2.340 ***
GDP	−0.00664 **	0.00272	−0.006	−0.001	−0.005	−0.40885 ***	0.04439	−0.408 **	−0.298	−0.604 *
INF	0.02610 ***	0.00406	0.026	0.018	0.027	0.42427 ***	0.05739	0.424	0.626 *	0.565
Lagged Shocks	1.53108 **	0.58791	1.531	−0.487	0.860	3.28703	7.18666	3.287	6.618	35.639
Constant	−0.08600 *	0.05193	−0.086	0.316	−0.947 *	−3.38993 ***	0.71536	−3.389	−21.454	−39.930 ***
Observations	1.268		1.268	45	45	1.268		1.268	45	45
R-squared	0.4924		0.4924			0.3717		0.3717		
Number of banks	233		233			233		233		

Note: QE^{std} denotes standardized quantitative easing. In the credit volatility specification, the transparency moderator is the annual change in standardized transparency ($\Delta\text{TRNS}^{\text{std}}$), and the interaction term is $\text{QE}^{\text{std}} \times \Delta\text{TRNS}^{\text{std}}$. In the credit-to-GDP gap specification, the moderator enters in levels (TRNSS), and the interaction term is $\text{QE}^{\text{std}} \times \text{TRNS}^{\text{std}}$. * Statistical significance at the 10% level ** Statistical significance at the 5% level *** Statistical significance at the 1% level.

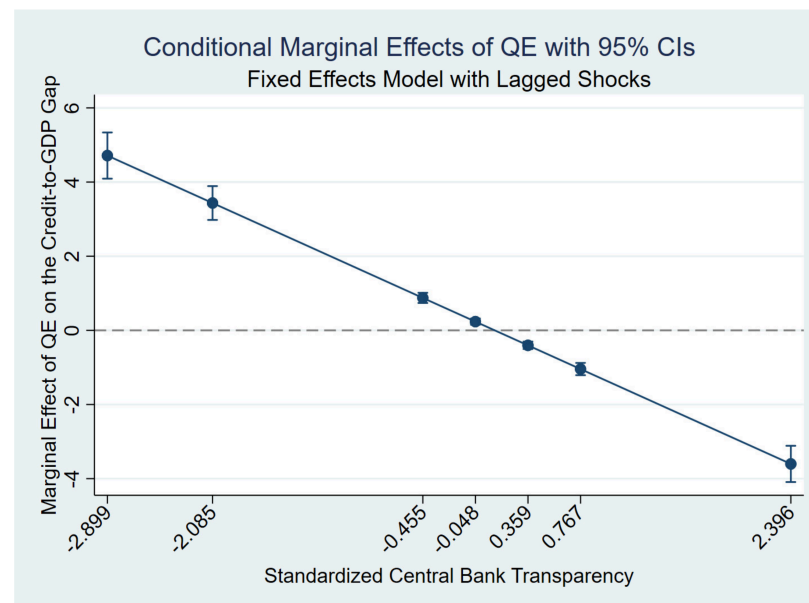


Figure 4. Conditional marginal effects of standardized QE on credit-to-GDP gap with Lagged Monetary-policy Shocks. Note: The grey dotted line indicates the zero-reference line.

The conditional marginal effects remain consistent after the inclusion of lagged monetary policy shocks. For credit volatility, the effect of QE^{std} declines from 0.150 at $\Delta TRNS^{std} = -0.815$, to 0.033 at $\Delta TRNS^{std} = 0$, and to -0.025 at $\Delta TRNS^{std} = 0.407$. For the credit-to-GDP gap, the corresponding effect decreases from 4.714 at $TRNS^{std} = -2.899$, to 0.235 around $TRNS^{std} = -0.048$, and to -3.603 at $TRNS^{std} = 2.396$. The marginal-effect profiles therefore confirm that the moderating role of transparency is not driven by the exclusion of lagged monetary policy shocks.

Figures 3 and 4 illustrate these conditional effects with 95% confidence intervals.

The variable lagged monetary shocks is positive and statistically significant in the credit volatility model, but it remains positive and statistically insignificant in the credit-to-GDP gap model. This means that delayed surprises in monetary policy affect short-term credit volatility but do not independently influence medium-term credit imbalances, depending on broader monetary policy conditions and macro-financial regulations. However, including lagged shocks provides an additional model that accounts for possible lagged spillover effects and omitted monetary policy shocks that could influence the banking sector over time.

Moreover, the coefficients of primary interest are not materially affected by the inclusion of lagged shocks. The positive and highly statistically significant coefficients for QE in both models underline the association between unconventional monetary expansion and higher vulnerability in the banking sector. Central bank transparency is likewise negative and statistically significant, supporting the argument that more transparent communication is positively associated with less financial fragility and more stable lending conditions.

In both models, the interaction term with QE and transparency continues to be negative and highly statistically significant. This result supports the main conclusion of the study that transparency mitigates the vulnerability-enhancing effects of unconventional monetary policy. In other words, accommodating monetary expansion can exacerbate credit dynamics and financial imbalances, but transparent communication and a higher degree of policy credibility seem to mitigate these destabilizing effects. This argument is consistent with the work of Jung and Uhlig (2019), Carvalho et al. (2025), and the research on the information and expectations channels of monetary policy transmission.

The other control factors continue to have economically significant effects. The coefficients of the credit volatility specification, of M3, and of GDP growth are negative and statistically significant, indicating that better liquidity conditions and better macroeconomic performance could reduce short-term instability in credit markets. CONC is positive but not statistically significant. Inflation is still positive and statistically significant, indicating that inflationary pressure could increase the short-run credit volatility. OBS remains positive but not statistically significant, providing little support to the hypothesis that non-traditional banking exposures may be a source of financial fragility (Kick & Prieto, 2015; Papanikolaou & Wolff, 2014).

In the credit-to-GDP gap model, M3 and banking concentration continue to be positive and statistically significant, suggesting that liquidity expansion and concentrated banking structures are associated with the build-up of medium-term credit imbalances. OBS is likewise positive and statistically significant. The coefficient for GDP growth is statistically significant and turns negative in this specification, suggesting that stronger economic activity may be associated with slower credit expansion relative to long-run economic fundamentals in the extended empirical specification. Overall, the M3 coefficient is sensitive to the estimation method. For credit volatility, it changes from positive and statistically insignificant in the System GMM model to negative and statistically significant in both fixed-effects specifications. For the credit-to-GDP gap, its sign remains positive across all models, although it is statistically significant only in the fixed-effects estimates. Overall, the results confirm the consistency of the link between QE, transparency, and banking sector vulnerability, controlling for lagged monetary policy shocks.

4.4. Fixed-Effects Estimates with Driscoll–Kraay Standard Errors

To assess whether the significance of the fixed-effects estimates is sensitive to correlated disturbances across banks and over time, the specifications in Tables 4 and 5 are re-estimated using Driscoll–Kraay standard errors with a maximum lag of one. The model specifications, samples, and coefficients remain unchanged, while the standard errors and significance levels are recalculated. Table 6 reports the results, which are interpreted cautiously given the short time dimension.

The QE–transparency interaction remains negative and statistically significant for both vulnerability indicators under Driscoll–Kraay inference. In Panel A, the coefficients are -0.113 for credit volatility and -1.623 for the credit-to-GDP gap. After including lagged monetary policy shocks, they remain significant at -0.143 and -1.571 , respectively. Thus, the negative interaction is preserved after accounting for heteroskedasticity, cross-sectional dependence, and first-order serial correlation.

The transparency moderator is also negative and statistically significant in all four specifications. QE^{std} is positive and significant for credit volatility but insignificant for the credit-to-GDP gap when standardized transparency equals zero. This confirms that QE should be interpreted through its conditional marginal effects rather than its main coefficient alone and shows that the central findings are not confined to conventional fixed-effects standard errors.

Lagged monetary policy shocks are statistically insignificant for both vulnerability indicators. Overnight interest rates remain positively associated with credit volatility and negatively associated with the credit-to-GDP gap. GDP growth is negative and significant only for the credit-to-GDP gap. OBS is positive and significant in both models without shocks, but loses significance for credit volatility when lagged shocks are included.

Overall, the Driscoll–Kraay estimates reduce the concern that the negative QE–transparency interaction reflects understated conventional standard errors. The coefficient signs and statistical significance remain stable after allowing for cross-sectional and serial

dependence. Nevertheless, because of the short time dimension, the estimates are treated as supplementary robustness evidence.

Table 6. Robustness Results Using Driscoll–Kraay Standard Errors.

Panel A. Fixed-Effects Specifications					
Dependent Variables	Credit Volatility			Credit-to-GDP Gap	
	Coeff.		Std. Error	Coeff.	Std. Error
QE ^{std}	0.02188	**	0.00754	0.14918	0.20475
TRNS ^{std}	−0.07760	**	0.01969	−0.78062	0.25179
QE ^{std} × TRNS ^{std}	−0.11271	***	0.02501	−1.62321	0.38958
STRovernight	0.11962	***	0.01288	−0.64713	0.07015
M3	−0.00176		0.00212	0.11160	0.05267
CONC	0.00015		0.00064	0.01819	0.01213
Δln(Total Assets)	0.00731		0.01990	0.00116	0.11369
EA	0.09169	*	0.03978	1.24605	0.51223
OBS	0.00866	***	0.00164	0.14552	0.04336
GDP	−0.00571		0.00892	−0.41993	0.08577
INF	0.01339	**	0.00490	0.38711	0.07153
Constant	−0.17108	*	0.06749	−3.40198	0.84155
Observations	1.330			1.330	
R-squared	0.5523			0.3706	
Number of banks	233			233	

Panel B. Fixed-Effects Specifications with Lagged Monetary Policy Shocks					
Dependent Variables	Credit Volatility			Credit-to-GDP Gap	
	Coeff.		Std. Error	Coeff.	Std. Error
QE ^{std}	0.03292	***	0.00491	0.16000	0.22705
TRNS ^{std}	−0.07728	**	0.02068	−0.82016	0.25429
QE ^{std} × TRNS ^{std}	−0.14328	***	0.02676	−1.57054	0.42598
STRovernight	0.10185	***	0.02676	−0.70901	0.16503
M3	−0.00276		0.00145	0.11032	0.05046
CONC	0.00016		0.00063	0.01849	0.01220
SIZE	0.01913		0.01264	0.04106	0.14648
EA	0.06260		0.05167	1.20297	0.44269
OBS	0.00419		0.00294	0.13836	0.03735
GDP	−0.00664		0.00557	−0.40885	0.09295
INF	0.02610		0.01527	0.42428	0.14566
Lagged Shocks	1.53108		2.09389	3.28704	11.26858
Constant	−0.08600	*	0.05532	−3.38993	0.75881
Observations	1.268			1.268	
R-squared	0.4924			0.3717	
Number of banks	233			233	

Notes: Driscoll–Kraay standard errors are reported. The maximum lag is set to one. All specifications include bank fixed effects. QE^{std} denotes standardized quantitative easing. In the credit volatility specifications, the transparency moderator is the annual change in standardized transparency, ΔTRNS^{std}, and the interaction term is QE^{std} × ΔTRNS^{std}. In the credit-to-GDP gap specifications, standardized transparency enters in levels, and the interaction term is QE^{std} × TRNS^{std}. * Statistical significance at the 10% level ** Statistical significance at the 5% level *** Statistical significance at the 1% level.

4.5. Disaggregated Dimensions of Central Bank Transparency

To examine whether the aggregate transparency index masks heterogeneous effects, the index is disaggregated into its five constituent dimensions: political, economic, procedural, policy, and operational transparency. Each dimension is entered separately into the

fixed-effects models. The complete estimates, including statistically insignificant, positive, and omitted interaction terms, are reported in Appendix Table A3.

The disaggregated estimates reveal considerable heterogeneity across the dimensions of central bank transparency. For credit volatility, operational transparency produces a negative and statistically significant interaction with QE, with the conditional effect changing from positive when operational transparency declines to negative when it remains unchanged. For the credit-to-GDP gap, procedural and policy transparency display negative and statistically significant interactions. In both cases, the marginal effect of QE declines as transparency increases and changes from positive at low transparency levels to negative at high levels. These qualitative patterns are also observed in the specifications including lagged monetary policy shocks.

The corresponding conditional marginal effects are presented in Figures 5–7. Each figure compares the fixed-effects specification with the corresponding model including lagged monetary policy shocks.

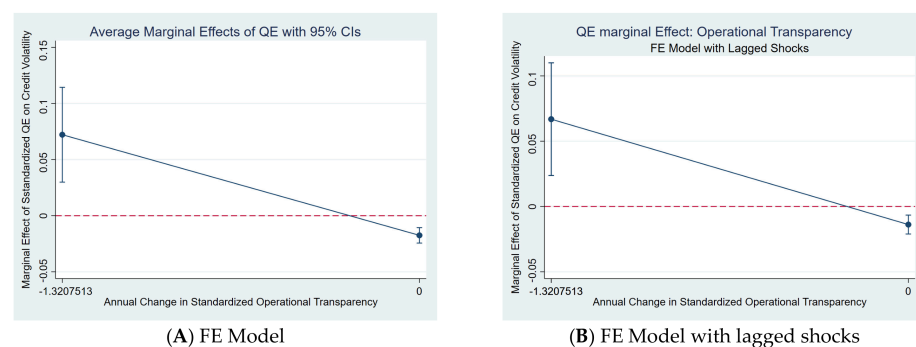


Figure 5. Operational transparency and credit volatility. Note: The red dotted line indicates the zero-reference line.

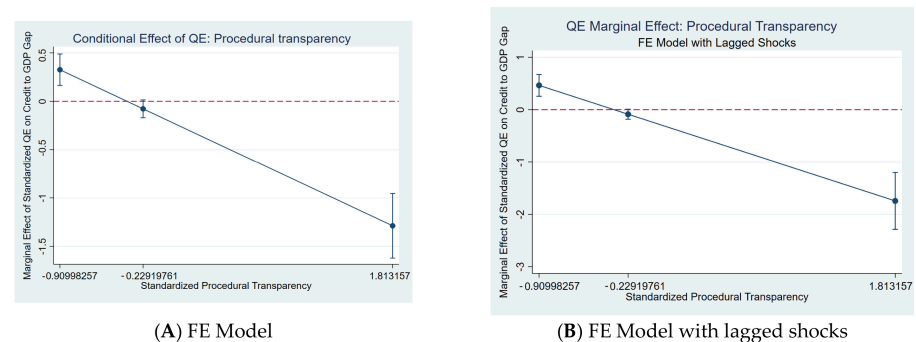


Figure 6. Procedural transparency and the credit-to-GDP gap. Note: The red dotted line indicates the zero-reference line.

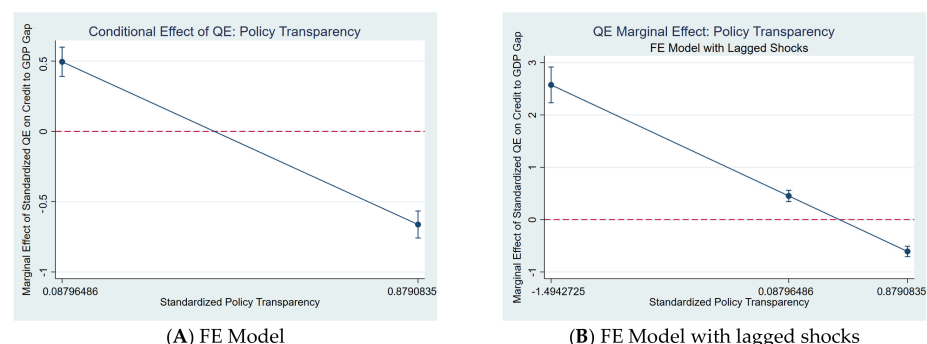


Figure 7. Policy transparency and the credit-to-GDP gap. Note: The red dotted line indicates the zero-reference line.

Political and economic transparency do not exhibit a consistent negative moderating pattern across the specifications, while operational transparency produces a positive interaction in the credit-to-GDP gap models.

5. Conclusions

In recent years, the stability of the banking sector has become a major concern for policymakers and banks. This is especially true as new monetary policies and changes in market functioning alter monetary transmission. Understanding the determinants of bank vulnerability remains important. Credit volatility and deviations from economic fundamentals can weaken banking system resilience and increase the risk of future crises.

Understanding what makes banks vulnerable is a central issue in macroprudential and monetary policy. Recent studies highlight credit volatility as a valuable early-warning indicator of financial instability, because sudden changes in credit growth and lending behavior often precede broader systemic stress (He et al., 2023; Oduncu et al., 2013). This approach fits with the broader emphasis placed on credit-based indicators within the macroprudential framework, such as the credit-to-GDP gap, which has become a widely used tool for tracking the build-up of systemic risk (Drehmann & Tsatsaronis, 2014).

Contagion can spread through balance sheet connections and fire-sale spillovers. Bank size, leverage, and shared exposures are all factors that make banks more vulnerable, even when traditional macro indicators appear stable (Greenwood et al., 2015).

This study examines the impact of monetary policy indicators, macroeconomic conditions, structural characteristics, and bank-specific factors on the vulnerability of the banking sector across 8 economies from 2013 to 2019. The empirical analysis, using a two-step System GMM framework complemented by fixed-effects specifications and models incorporating lagged monetary policy shocks, provides evidence that monetary policy conditions and central bank transparency are associated with banking system vulnerability.

The empirical findings underscore the dual function of monetary policy in influencing the vulnerability of the banking sector. Although unconventional measures like QE facilitate credit availability and stimulate economic activity in the short term, they may concurrently exacerbate financial imbalances by increasing credit volatility and expanding the credit-to-GDP gap. These results are consistent with the bank risk-taking channel, whereby prolonged periods of accommodative monetary policy can lead to more leverage, riskier balance sheets, and more interconnected exposures.

This research makes a contribution, by identifying the conditional role of central bank transparency in the link between QE and banking system vulnerability. At the aggregate level, transparency is adversely related to vulnerability and pushes the marginal effect of QE in a more negative direction. More specifically, at lower levels of transparency, QE is associated with greater credit volatility and wider credit-to-GDP gaps; however, as transparency increases, this positive association weakens and may become negative at sufficiently high levels. By offering clearer information about the objectives, implementation, and expected duration of QE, central bank transparency can reduce uncertainty, curb excessive risk-taking, and help prevent destabilizing credit developments.

The study also contributes to the literature by demonstrating that the financial stability effects of QE depend not only on the aggregate level of central bank transparency, but also on the specific dimension of transparency considered. The disaggregated analysis indicates that this moderating link is not consistent across all characteristics of transparency. Operational transparency is the strongest negative moderating link in the credit volatility specifications, whereas procedural and policy transparency are the strongest negative moderating associations in the credit-to-GDP gap models among the three types of transparency. Other dimensions provide statistically insignificant, omitted, or opposite signed

interaction terms, pointing to a large variation in the routes through which transparency acts. The negative QE–transparency association remains when inference is corrected for heteroskedasticity, serial correlation and cross-sectional dependence using Driscoll–Kraay standard errors.

The component-level findings further suggest that transparency reforms should not be treated as a one-dimensional policy instrument. Procedural and policy transparency appear particularly relevant for weakening the positive association between QE and medium-term credit imbalances, whereas changes in operational transparency are more closely associated with short-term credit volatility. Because operational transparency produces different patterns across the two vulnerability indicators, communication reforms should be calibrated to the specific financial stability channel rather than assumed to generate uniformly stabilizing effects.

The results have significant implications for the design of monetary policy. Central banks that undertake QE or other large-scale accommodation should incorporate financial stability considerations into the evaluation, communication and withdrawal of such policies. Because QE is connected positively with credit volatility and the credit-to-GDP gap, policy evaluations need to go beyond GDP and inflation to credit growth, the dispersion of lending, leverage and balance sheet risks. Thus, communication should clear both the desired macroeconomic consequences and the financial stability risks being monitored, as well as the parameters under which policy may be changed.

Transparency should be a tool to macroprudential intervention, not a substitute for it. Where accommodating policy overlaps with rapid credit expansion or increased credit volatility, authorities may need stronger monitoring, stress testing and customized instruments such as countercyclical capital buffers and sector-specific measures. Better monetary–macroprudential cooperation can help to manage the build-up of imbalances without withdrawing support from the broader economy too early. The communication should be clear, timely, and state-contingent, without inflexible pre-commitment but with flexibility, and it should limit ambiguity and maintain confidence.

The findings do not suggest that banks and central banks would behave similarly in future QE periods. Rather, past experience may make banks more prepared, and central banks may adapt their transparency and communication efforts to better deal with the financial stability risks associated with unconventional monetary policy.

At the same time, these outcomes should be interpreted in light of several empirical and structural factors. The analysis concentrates on a particular set of vulnerability indicators and a pre-pandemic sampling period, which may not fully reflect the dynamic evolution of banking risks during recent monetary-tightening cycles or structural changes in financial intermediation. These elements are inherent extensions of the existing framework, without diminishing the main findings concerning the interplay between monetary policy, transparency, and the vulnerability of the banking sector.

Although the empirical analysis offers substantial evidence about the interplay between monetary policy, central bank transparency, and banking sector risk, several limitations must be recognized. These constraints mainly concern measurement and sample scope, and they suggest directions for future research.

The analysis may also be affected by endogeneity. Although the empirical approach is designed to mitigate this concern, broader macro-financial factors may simultaneously influence monetary policy, central bank transparency, and banking vulnerability. The coefficients should therefore be interpreted cautiously with respect to causality.

A final constraint concerns the assessment of bank vulnerability. The study depends on aggregate indicators like credit volatility and the credit-to-GDP gap. These indicators capture systemic and macro-financial imbalances, but they do not fully capture differ-

ences in bank-level risk exposure. Future research may improve these measures by using additional indicators, such as market-based risk metrics.

The study's concentration on a specific group of countries and a pre-pandemic period may limit the generalizability of the results. Expanding the analysis to include post-pandemic monetary tightening cycles or emerging economies could provide additional insights into the functioning of transparency and unconventional policies within varying institutional and macro-financial contexts.

Author Contributions: Conceptualization, I.D., A.K. and E.S. Methodology, I.D., A.K. and E.S. Software, A.K. Validation, E.S. Formal analysis, I.D., A.K. and E.S. Investigation, Resources, I.D., A.K. and E.S. Data curation, A.K. Writing—original draft preparation, I.D., A.K. and E.S. Writing—review and editing, I.D., A.K. and E.S. Visualization, A.K. Supervision, I.D. Project administration, E.S. Funding acquisition, I.D. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

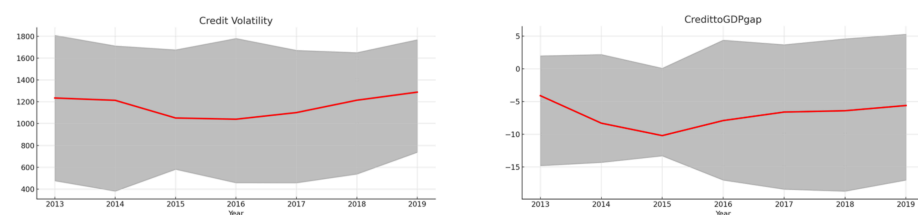


Figure A1. Annual evolution of credit volatility and the credit-to-GDP gap, 2013–2019.

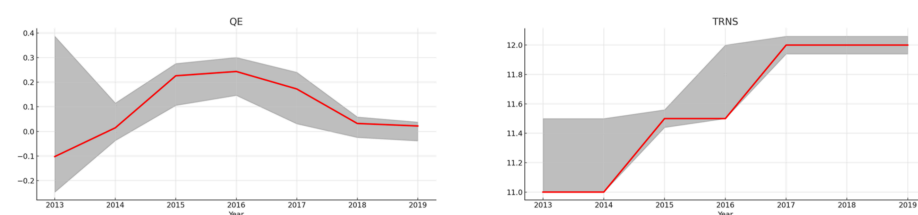


Figure A2. Annual evolution of quantitative easing (QE) and central bank transparency (TRNS), 2013–2019.

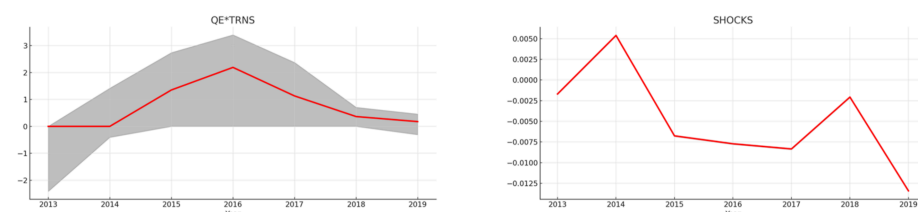


Figure A3. Annual evolution of the QE–transparency interaction and monetary policy shocks, 2013–2019.

Table A1. Descriptive Statistics: means and standard deviation of independent variables.

Country	Variable	SIZE	EA	OBS	STR	M3	QE	TRNS	GDP	INF	CONC
Austria	Mean	16.52257	0.07639	14.4227	−0.4057	4.02121	0.05567	11.5714	1.44130	1.57209	63.9897
	St. Dev	(1.1008)	(0.0627)	(1.9037)	(0.2481)	(1.546)	(0.0999)	(0.4176)	(0.8734)	(0.4713)	(6.078)
Belgium	Mean	16.76261	0.19523	15.2307	−0.2242	4.02121	0.10080	11.5714	1.50572	1.37204	65.0311
	St. Dev	(2.0379)	(0.2842)	(2.9394)	(0.2059)	(1.5472)	(0.234)	(0.4179)	(0.482)	(0.6772)	(2.088)
Denmark	Mean	15.59144	0.13935	13.1964	−0.3126	2.82083	−0.03764	8.57142	2.28402	0.682	83.9922
	St. Dev	(1.934)	(0.1558)	(1.711)	(0.2364)	(9.1086)	(0.0509)	(0.4966)	(0.7408)	(0.2693)	(3.5126)
Finland	Mean	15.17476	0.15873	12.9708	0.14285	4.02121	−0.07728	11.5714	1.12365	0.79002	87.7649
	St. Dev	(1.9242)	(0.2468)	(2.5591)	(0.2646)	(1.5543)	(0.2195)	(0.4198)	(1.4174)	(0.52)	(9.2118)
France	Mean	17.78539	0.10182	15.9666	−0.2242	4.02121	0.07805	11.5714	1.33339	0.79766	58.7431
	St. Dev	(1.4171)	(0.091)	(1.6482)	(0.2055)	(1.544)	(0.1571)	(0.4171)	(0.5326)	(0.5745)	(1.6601)
Spain	Mean	16.97587	0.09005	14.3962	−0.2242	4.02121	0.05838	11.5714	2.02411	0.69789	61.8643
	St. Dev	(1.9518)	(0.0825)	(2.4919)	(0.2057)	(1.5453)	(0.1943)	(0.4174)	(1.5957)	(0.9287)	(5.9053)
Sweden	Mean	16.37751	0.08883	14.1151	−0.0685	6.10302		14.5	2.32760	0.89224	91.5953
	St. Dev	(2.0328)	(0.0754)	(2.7047)	(0.4777)	(2.493)		(0.0)	(1.0236)	(0.9029)	(0.373)
USA	Mean	17.48137	0.11175	16.7933	0.87285	5.70763	0.06138	12.5	2.37790	1.55031	35.1844
	St. Dev	(1.7927)	(0.0233)	(2.2433)	(0.7832)	(0.9684)	(0.1438)	(0.0)	(0.4892)	(0.6922)	(0.4886)

Table A2. Conditional marginal effects of standardized QE.

Panel A. Baseline Fixed-Effects Models							
Vulnerability Measure	Transparency Moderator	Moderator Value	Marginal Effect of QE	Std. Error	z-Statistic	p-Value	95% Confidence Interval
Credit volatility	Δ TRNS (std. units)	−0.815	0.114	0.014	7.91	<0.001	[0.086, 0.142]
Credit volatility	Δ TRNS (std. units)	0.000	0.022	0.004	5.45	<0.001	[0.014, 0.030]
Credit volatility	Δ TRNS (std. units)	0.407	−0.024	0.005	−5.33	<0.001	[−0.033, −0.015]
Credit-to-GDP gap	TRNS (std. units)	−2.899	4.856	0.296	16.42	<0.001	[4.276, 5.435]
Credit-to-GDP gap	TRNS (std. units)	−2.085	3.533	0.217	16.30	<0.001	[3.108, 3.958]
Credit-to-GDP gap	TRNS (std. units)	−0.455	0.888	0.066	13.39	<0.001	[0.758, 1.018]
Credit-to-GDP gap	TRNS (std. units)	−0.048	0.071	0.040	1.80	0.072	[−0.006, 0.149]
Credit-to-GDP gap	TRNS (std. units)	0.359	−0.434	0.047	−9.16	<0.001	[−0.527, −0.341]
Credit-to-GDP gap	TRNS (std. units)	0.767	−1.095	0.077	−14.20	<0.001	[−1.246, −0.944]
Credit-to-GDP gap	TRNS (std. units)	2.396	−3.740	0.229	−16.30	<0.001	[−4.190, −3.290]
Panel B. Fixed-Effects Models with Lagged Annual Federal Reserve Monetary-Policy Shock							
Vulnerability Measure	Transparency Moderator	Moderator Value	Marginal Effect of QE	Std. Error	z-Statistic	p-Value	95% Confidence Interval
Credit volatility	Δ TRNS (std. units)	−0.815	0.150	0.016	9.43	<0.001	[0.119, 0.181]
Credit volatility	Δ TRNS (std. units)	0.000	0.033	0.004	7.43	<0.001	[0.024, 0.042]
Credit volatility	Δ TRNS (std. units)	0.407	−0.025	0.005	−5.59	<0.001	[−0.034, −0.017]
Credit-to-GDP gap	TRNS (std. units)	−2.899	4.714	0.318	14.82	<0.001	[4.090, 5.337]
Credit-to-GDP gap	TRNS (std. units)	−2.085	3.434	0.233	14.76	<0.001	[2.978, 3.890]
Credit-to-GDP gap	TRNS (std. units)	−0.455	0.875	0.070	12.54	<0.001	[0.738, 1.012]
Credit-to-GDP gap	TRNS (std. units)	−0.048	0.235	0.043	5.43	<0.001	[0.151, 0.320]
Credit-to-GDP gap	TRNS (std. units)	0.359	−0.404	0.051	−7.91	<0.001	[−0.504, −0.304]
Credit-to-GDP gap	TRNS (std. units)	0.767	−1.044	0.084	−12.41	<0.001	[−1.209, −0.879]
Credit-to-GDP gap	TRNS (std. units)	2.396	−3.603	0.249	−14.44	<0.001	[−4.092, −3.114]

Notes: The table reports average marginal effects of standardized quantitative easing (QE) evaluated at representative observed values of the transparency moderator. For credit volatility, the moderator is the annual change in standardized central bank transparency (Δ TRNS). For the credit-to-GDP gap, it is standardized central bank transparency in levels (TRNS). Standard errors and confidence intervals are calculated using the delta method. Panel A is based on 1330 observations; Panel B is based on 1268 observations. Values reported by Gretl 2026b as 0.000 are presented as $p < 0.001$.

Table A3. Component-level fixed-effects estimates of central bank transparency.

Panel A. Credit Volatility—Fixed Effects				
Transparency Dimension	QE	Transparency Component	QES × Transparency Component	Within R²
Political	−0.0058 * (0.0032)	Omitted	Omitted	0.4907
Economic	−0.0056 * (0.0032)	0.0070 (0.0172)	Omitted	0.4908
Procedural	0.0009 (0.0033)	0.0017 (0.0172)	−0.1057 *** (0.0232)	0.5159
Policy	−0.0102 ** (0.0044)	−0.0608 *** (0.0061)	0.0020 (0.0080)	0.5345
Operational	−0.0175 *** (0.0035)	0.0100 (0.0091)	−0.0679 *** (0.0170)	0.5174
Panel B. Credit-to-GDP Gap—Fixed Effects				
Transparency Dimension	QES	Transparency Component	QES × Transparency Component	Within R²
Political	−0.3335 *** (0.0656)	Omitted	0.6795 *** (0.0995)	0.2440
Economic	0.2792 *** (0.0734)	−0.5270 ** (0.2299)	−0.9278 *** (0.1953)	0.2282
Procedural	−0.2136 *** (0.0464)	0.8153 *** (0.1896)	−0.5926 *** (0.0856)	0.2907
Policy	0.6236 *** (0.0579)	−0.4905 *** (0.1343)	−1.4632 *** (0.0786)	0.4375
Operational	−0.0243 (0.0432)	0.4747 *** (0.1697)	0.9688 *** (0.1240)	0.2541
Panel C. Credit Volatility—Fixed Effects with Lagged Shocks				
Transparency Dimension	QES	Transparency Component	QES × Transparency Component	Within R²
Political	−0.0034 (0.0033)	Omitted	Omitted	0.4123
Economic	−0.0032 (0.0033)	0.0088 (0.0175)	Omitted	0.4125
Procedural	0.0035 (0.0036)	0.0093 (0.0191)	−0.1080 *** (0.0235)	0.4345
Policy	−0.0019 (0.0048)	−0.0565 *** (0.0062)	−0.0127 (0.0086)	0.4627
Operational	−0.0138 *** (0.0037)	0.0057 (0.0093)	−0.0611 *** (0.0174)	0.4334
Panel D. Credit-To-GDP Gap—Fixed Effects With Lagged Shocks				
Transparency Dimension	QES	Transparency Component	QES × Transparency Component	Within R²
Political	−0.2646 *** (0.0983)	Omitted	0.5656 *** (0.1594)	0.2432
Economic	0.0872 (0.0969)	−0.1688 (0.2624)	−0.1658 (0.3121)	0.2342
Procedural	−0.2739 *** (0.0564)	0.7556 *** (0.1975)	−0.8106 *** (0.1351)	0.2924
Policy	0.5705 *** (0.0603)	−0.8342 *** (0.1504)	−1.3412 *** (0.0839)	0.4522
Operational	−0.0104 (0.0467)	0.4473 ** (0.1863)	0.8839 *** (0.1723)	0.2532

Notes: Coefficients are reported with conventional standard errors in parentheses. For credit volatility, the transparency component is the annual change in the standardized dimension; for the credit-to-GDP gap, it is the standardized level. All specifications include bank fixed effects and the controls dSIZE, EA, OBS, i_CONC, GDP, INF, i_STRovernight, and M3. “Omitted” denotes a term not estimated because of perfect collinearity. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Note

- ¹ The real interest rate also affects bank vulnerability. Hamdaoui and Maktouf (2020) show that when real rates lower, credit booms may come. However, when real rates increase, default risk rises and loan portfolios start to decrease. The Adrian and Oura (2023) indicates the same direction. Higher rates compress margins. They bring valuation losses and push up provisioning needs. These pressures add to the fragility of the banking system. The real rate feeds directly into the stresses that banks must manage.

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